SCIENCE, AERONAUTICS, AND TECHNOLOGY
FY 2003 ESTIMATES
BUDGET SUMMARY

OFFICE OF EARTH SCIENCE

Web Address: http://earth.nasa.gov/

SUMMARY OF RESOURCE REQUIREMENTS

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET	PAGE NUMBER
		(Millions of Dollars)		
Major Development	**852.2**	**752.6**	**556.4**	SAT 3-2
Earth Observing System	431.5	385.4	410.9	SAT 3-14
Earth Observing System Data Information System	279.1	293.0	74.3	SAT 3-67
Earth Explorers	141.6	74.2	71.2	SAT 3-74
Research and Technology	**564.2**	**537.1**	**506.3**	SAT 3-89
Earth Science Program Science	350.2	340.5	353.9	SAT 3-91
Applications, Education and Outreach	114.1	94.8	61.7	SAT 3-100
Technology Infusion	99.9	101.8	87.3	SAT 3-109
Construction of Facilities	--	--	3.4	SAT 3-118
Mission Operations	**57.8**	**47.6**	**247.8**	SAT 3-119
Investments	**10.3**	**--**	**--**	SAT 3-123
Minority University Research & Education Program	8.8	--	--	
Education	1.5	--	--	
Institutional Support	**277.7**	**288.4**	**317.9**	SAT 3-125
Total	**1,762.2**	**1,625.7**	**1,628.4**	
Total Direct Civil Servant Full-Time Equivalent (FTE) Work Years	**1,913**	**1,747**	**1,848**	

OFFICE OF EARTH SCIENCE

DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
Johnson Space Center.....	35.2	21.3	18.2
Kennedy Space Center.....	84.0	52.8	53.2
Marshall Space Flight Center	18.0	26.3	25.7
Ames Research Center	33.2	32.8	33.8
Langley Research Center	141.5	156.1	138.8
Glenn Research Center	3.0	1.4	0.4
Goddard Space Flight Center	1,049.4	957.7	996.9
Jet Propulsion Laboratory	208.3	178.9	161.3
Dryden Flight Research Center	23.9	25.6	20.6
Stennis Space Center	83.8	57.9	42.3
Headquarters	81.9	114.9	137.2
Total	**1,762.2**	**1,625.7**	**1,628.4**

EARTH SCIENCE STRATEGIC PLAN LINKAGE TO THIS BUDGET

The mission of NASA's Earth Science Enterprise (ESE) is to develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations. NASA brings to this endeavor the vantage point of space, allowing global views of Earth system change. NASA is a provider of objective scientific information, via observation, research, modeling, and applications demonstration, for use by decision-makers in both the public and private sectors. NASA has been studying the Earth from space from its beginnings as an Agency. These efforts have led to our current activity of deploying the first series of Earth Observing System (EOS) satellites that will concurrently observe the major interactions of the land, oceans, atmosphere, ice, and life that comprise the Earth system. In short, the purpose of the ESE is to provide scientific answers to the fundamental question:

How is the Earth changing, and what are the consequences for life on Earth?

A fundamental discovery made during the 20th century, enabled in large part by NASA's global view from space, is the existence of a multiplicity of linkages between diverse natural phenomena and interactions between the individual components of the Earth system. As a result, NASA has worked with other agencies to develop a new, interdisciplinary field of "Earth System Science", with

the aim of investigating the complex behavior of the total Earth environment in which the global atmosphere, the oceans, the solid Earth, the ice-covered regions of the Earth, and the biosphere all function as a single interactive system. Earth System Science is an area of research with immense benefits to the nation, yielding new knowledge and tools for weather forecasting, agriculture, water resource management, urban and land use planning, and other areas of economic and environmental importance. In concert with other agencies and the global research community, ESE is providing the scientific foundation needed for the complex policy choices that lie ahead on the road to sustainable development.

ESE has established three broad goals through which to carry out its mission. 1) Science: Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth; 2) Applications: Expand and accelerate the realization of economic and societal benefits from Earth science, information and technology; 3) Technology: Develop and adopt advanced technologies to enable mission success and serve national priorities. These goals are articulated in the ESE Strategic Plan.

NASA and its partners have already made considerable progress in understanding the Earth system. With satellites launched over the past decade, ESE has charted global ocean circulation including the waxing and waning of El Niño, mapped land cover change over the entire globe, illuminated the 3-D structure of hurricanes, and explored the chemistry of the upper atmosphere, as well as the causes of ozone depletion. With deployment of the EOS now underway, ESE is opening a new era in Earth observation from space in which the major interactions of the Earth system are studied simultaneously to provide a global view on climate change. With this knowledge, NASA and its partners will develop prediction capabilities to quantify the effects of natural and human-induced changes on the global environment. Operational agencies such as National Oceanic and Atmospheric Administration (NOAA) and United States Geological Survey (USGS), who are partners in this effort, can use these capabilities to improve weather and climate forecasting, natural resource management, and other services on which the Nation relies.

STRATEGY FOR ACHIEVING GOALS

SCIENCE

We know that natural and human-induced changes are acting on the Earth system. Natural forces include variation in the Sun's energy output and volcanic eruptions, which spew dust into the atmosphere and scatter incoming sunlight. Human forces include deforestation, carbon emission from burning of fossil fuels, methane and soil dust production from agriculture, and ozone depletion by various industrial chemicals. Internal climate factors such as atmospheric water vapor and clouds also introduce feedbacks that serve to either dampen or enhance the strength of climate forcing. We also know the climate system exhibits considerable variability in time and space, i.e., both short and long term changes and regionally specific impacts. For example, we have observed that over the past twenty years, the growing season has lengthened in much of the northern latitudes while Arctic sea ice extent has experienced a net decrease. Behind these net changes are considerable variations by region. Recent research has shown that dust aerosols in the atmosphere tend to slow the rate of evaporation and precipitation, while rising temperatures are expected to accelerate them. Distinguishing trends in the midst of substantial variability and countervailing forces, and distinguishing natural from human-induced changes, pose some of the challenges undertaken by ESE.

NASA has used the concept of Earth System Science in developing its program. Researchers have constructed computer models to simulate the Earth system, and to explore the possible outcomes of potential changes they introduce in the models. This way of looking at the Earth as a system is a powerful means of understanding changes we see around us. This has three implications for Earth Science. First, we need to ***characterize*** (that is, identify and measure) the forces acting on the Earth system and its responses. Second, we need to ***understand*** the source of internal variability: the complex interplay among components that comprise the system. Finally, by combining observations, research and modeling, we create a capability to ***predict*** Earth system change to help our partners produce better forecasts of change.

Earth system changes are global phenomena. Yet the system comprises many micro-scale processes, and the most significant manifestations are regional. Thus, studying such changes requires a global view at regionally discerning resolutions. This is where NASA comes in, bringing the unique capability to study planet Earth from the vantage point of space. To *characterize* the forces acting on the Earth system and its responses, *understand* the source of internal variability and *predict* Earth system change, NASA must observe the Earth, conduct research and analysis of the data, model the data and synthesize the information into new knowledge. Where we are on this knowledge "life cycle" determines the strategy for our investment decisions.

The ESE is pursuing a targeted research program, focused on a set of specific science questions that can be addressed effectively with NASA's capabilities. ESE formulates comprehensive research strategies that can lead to definitive scientific answers and potentially to effective applications by other entities.

The key Earth Science research topics sponsored by NASA follow from this view of the Earth as a system. Thus they are grouped into categories of variability in the Earth System, forces acting on the Earth system, responses of the system to change, consequences of change, and prediction of future changes. Complicating this seemingly linear construct is a set of feedbacks; responses to change often become forces of additional change themselves. This conceptual approach applies in essence to all research areas of NASA's ESE and is particularly relevant to the problem of climate change, a major Earth Science-related challenge facing our nation and the rest of the world. The ESE has articulated an overarching question and a set of strategic science questions reflecting this Earth system approach, which its observational programs, research and analysis, modeling, and advanced technology activities are directed at answering**.**

How is the Earth system changing, and what are the consequences for life on Earth?

- *How is the global Earth system changing? (Variability)*
- *What are the primary causes of change in the Earth system? (Forcing)*
- *How does the Earth system respond to natural and human-induced changes? (Response)*
- *What are the consequences of changes in the Earth system for human civilization? (Consequences)*
- *How can we predict future changes in the Earth system? (Prediction)*

ESE's Research Strategy for 2000-2010 describes NASA's approach to answering these questions. The intellectual capital behind ESE missions, and the key to generating new knowledge from them, is vested in an active program of research and analysis. Over 1,500 scientific research tasks from nearly every state within the U.S. are funded by the ESE research and analysis program. Scientists from seventeen other nations, funded by their own countries and collaborating with U.S. researchers, are also part of the ESE program. These researchers develop Earth system models from Earth science data, conduct laboratory and field experiments, run aircraft campaigns, develop new instruments, and thus expand the frontier of our understanding of our planet. ESE-funded scientists are recognized as world leaders in their fields, as exemplified by the award of the 1995 Nobel Prize in chemistry to two scientists who first recognized that chlorofluorocarbons provided a threat to upper atmospheric ozone. The research and analysis program is also the basis for generation of application pilot programs that enable universities, commercial firms, as well as state and local governments to turn scientific understanding into economically valuable products and services.

APPLICATIONS

NASA expects that expanded scientific knowledge of Earth processes and the utilization of advanced space-based and airborne observing techniques or facilities developed by NASA lead to practical applications beneficial to all citizens. Examples of these applications include: quantitative weather and hydrologic forecasts over an extended range of one to two weeks; prediction of seasonal or longer-range climate variations; the prediction of impacts of environmental changes on fisheries, agriculture, and water resources; global air quality forecasts and natural hazards risk assessments. NASA ESE has a role in demonstrating the potential applications.

ESE continues to build a viable applications program that bridges focused research and analysis and mission science investments towards demonstration of new remote sensing data products for industry, as well as regional and local decision makers. The emphasis is on helping weather forecasters, natural resource managers, disaster preparedness managers, and other decision and policy makers at the Federal, State and local levels to incorporate Earth science information in to their own decision support systems. The baseline Applications program provides the essential tools and funds key demonstration projects.

A series of regional workshops have been held around the Nation. These workshops enable a wide variety of State and local government users to share the challenges they face and explore the use of satellite remote sensing tools to address their challenges. One result is the establishment of regular, open, competitively selected opportunities for these organizations to propose partnerships with NASA, academia and industry. These partnerships will demonstrate new applications of Earth science data to specific problems. Successful demonstrations are expected to lead to new commercial as well as state and local government transactions, while ESE moves on to the next new demonstration activity.

TECHNOLOGY

In addition to ensuring a robust science program, this budget contains a focused Technology Program that supports development of key technologies to enable our future science missions. The baseline Technology Program includes the New Millennium Program (NMP), Instrument Incubator and advanced information systems and computing elements. The Technology Program also includes a

focused Advanced Technology Initiative Program that identifies and invests in critical instrument, spacecraft and information system technologies.

The ESE will lead the way in the development of highly capable, remote and *in situ* instruments as well as the information system technologies needed to support its science and applications objectives. Together they will enable affordable investigation and broad understanding of the global Earth system. The ESE emphasizes the development of information system architectures. These architectures will increase the number of users of ESE information from thousands to millions, with the goal of providing easy access to global information for science, education, and applications. Finally, ESE will work in partnership with industry and operational organizations to develop the capabilities and infrastructure to facilitate the transition of sustained measurements and information dissemination to commercial enterprises.

ESE's technology strategy seeks to leverage the entire range of technology development programs offering benefits in cost, performance and timeliness of future Earth science process and monitoring campaigns. ESE's strategy is to establish strong links to other government programs in order to maximize mutual benefit and to use open competitions for ESE-sponsored technology programs to attract the best ideas and capabilities from the broad technology community, including industry and academia.

Technology investments will be made in the following areas:

- Advanced instrument and measurement technologies for new and/or lower cost scientific investigations;
- Cutting-edge technologies, processes, techniques, and engineering capabilities that reduce development, operations costs, and mission risk that support rapid implementation of productive, economical, and timely missions;
- Advanced end-to-end mission information system technologies that will have an impact on the data flow from origination at the instrument detector through data archiving. These technologies will collect and disseminate information about the Earth system and enable the productive use of ESE science and technology in the public and private sectors.

MISSION IMPLEMENTATION

The pursuit of Earth System Science would be impractical without the continuous, global observations provided by satellite-borne instruments. NASA's Earth science research program comprises an integrated slate of spacecraft and suborbital measurement capabilities; data and information management systems to acquire, process, archive and distribute global data sets; and research and analysis projects to convert data into new knowledge of the Earth system. Numerous users in academia, industry, as well as Federal, State, and local governments use this knowledge to produce products and services essential to achieving sustainable development. The ESE top priority continues to be the commitments to launch the first series of EOS and selected Earth Explorer missions that are nearing completion. In addition, ESE is committed to evolving functioning data and information systems to support the processing, archival, and distribution of data products for these missions. These satellites will propel the ESE into a new era of data collection, research, and analysis for which both the national and international Earth science community has been preparing over the last decade.

PARTNERSHIPS ARE ESSENTIAL TO SUCCESS IN EARTH SCIENCE

The challenge of Earth System Science, sustainable development, and mitigating risk to people, property and the environment from natural disasters, requires collaborative efforts among a broad range of national and international partners. NASA's Earth science research program constitutes its contribution to the U.S. Global Change Research Program (USGCRP), an interagency effort to understand the processes and patterns of global change. The USGCRP coordinates research among ten U.S. government agencies. NASA is the major partner in the USGCRP, providing the bulk of the USGCRP space-based observational needs. NASA will also participate in the Climate Change Research Initiative (CCRI) announced by the President in June 2001. The CCRI will focus on answering key gaps in knowledge, will adopt performance metrics for accountability, and will deliver products useful to policymakers in a short timeframe (2-5 years). NASA has extensive collaboration with the NOAA on weather and climate-related programs. The ESE is the responsible managing agent in NASA for the development of the NOAA operational environmental satellites. NOAA, NASA, and the Department of Defense (DoD) are working together to achieve the convergence of civilian and military weather satellite systems and extend selectively some observations required by climate research to the future operational systems. NASA collaborates with the USGS on a range of land surface, solid Earth and hydrology research projects. NASA and USGS continue to collaborate on the Landsat-7 program. In addition, NASA participates in the international programs of World Climate Research, the International Geosphere/Biosphere, and the World Meteorological Organization.

International cooperation is an essential element in the Earth science program. Earth science addresses global issues and requires international involvement in its implementation and application. Acquiring and analyzing the information necessary to address the science questions is a bigger task than a single nation can undertake. Furthermore, the acceptance and use of the scientific knowledge in policy and resource management decisions around the world require the engagement of the international scientific community. Global data and global participation are needed to devise a global response to environmental change. In addition, integrating our complementary science programs can result in fiscal benefits to the NASA program. For this reason, NASA has sought and nurtured international partnerships spanning science, data and information systems, and flight missions. Most of the ESE satellite missions have international participation, ranging from simple data sharing agreements to joint missions involving provision of instruments, spacecraft, and launch services. In the past three years over 60 international agreements have been concluded and more than 40 more are pending. In some capacity, Earth science programs involve international partners from over 35 nations, including Argentina, Armenia, Australia, Belgium, Brazil, Canada, Chile, China, Denmark, Egypt, France, Germany, India, Israel, Italy, Japan, Mongolia, Russia, South Africa, Ukraine, and others.

In order to structure the scientific research, the ESE has established goals, objectives, research focus areas and programs. The ESE is currently developing roadmaps for how to achieve its science objectives. Until the roadmaps are completed, the phrase "increase understanding" is being used as a placeholder in the research focus areas.

Enterprise Goals	Science Objectives	Research Focus Areas	Enabling Program/Mission
Observe, understand, and model the Earth system to learn how it is changing, and the consequence for life on Earth.	Discern and describe how the global Earth system is changing.	Increase understanding of global precipitation, evaporation and how the cycling of water through the Earth system is changing.	TRMM, Aqua, NPP
		Increase understanding of global ocean circulation and how it varies on interannual, decadal, and longer time scales by meeting 2 of 2 performance indicators.	Aqua, SeaWinds, Ocean Topography, TOPEX, Jason-1, Grace, ground networks
		Increase understanding of global ecosystems change.	SeaWifs, Terra, Aqua, NPP
		Increase understanding of stratospheric ozone changes, as the abundance of ozone-destroying chemicals decreases and new substitutes increases.	Aura, TOMS and SAGE
		Increase understanding of change occurring in the mass of the Earth's ice cover.	ICESat, aircraft campaigns, Quikscat, DMSP
		Increase understanding of the motions of the Earth, the Earth's interior, and what information can be inferred about the Earth's internal processes.	VLBI/SLR networks, Magnetometer/Global Positioning System (GPS) constellation, Grace, SCIGN
	Identify and measure the primary causes of change (forcings) in the Earth system.	Increase understanding of trends in atmospheric constituents and solar radiation and the role they play in driving global climate.	Terra, TOMS, SAGE, AGAGE, ACRIMSat, SORCE, UARS, NPP, CALIPSO

Enterprise Goals	Science Objectives	Research Focus Areas	Enabling Program/Mission
		Increase understanding about the changes in global land cover and land use and their causes	Terra, Landsat, LDCM, NPP
		Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes.	SRTM, EO-1, Landsat, Terra, SAR observations and ground based networks, space GPS receivers
	Determine how the Earth system responds to natural and human-induced changes	Increase understanding of the effects of clouds and surface hydrologic processes on climate change	CloudSat, CALIPSO, Aqua, Terra, Seawinds, ACRIMSat, NPP
		Increase understanding of how ecosystems respond to and affect global environmental change and affect the global carbon cycle	Aqua, Terra, NPP
		Increase understanding of how climate variations induce changes in the global ocean circulation	SeaWinds, TOPEX, Quickscat, Jason-1
		Increase understanding of stratospheric trace constituents and how they respond to change in climate and atmospheric composition	SOLVE, Aura, TOMS, SAGE
		Increase understanding of global sea level and how it is affected by climate change	RADARSAT, ERS 1 and 2
		Increase understanding of the effects of regional pollution on the global atmosphere, and the affects of global chemical and climate changes on regional air quality.	TRACE-P, TOMS, SAGE, Aura, Terra
	Identify the consequences of change in the Earth system for human civilization.	Increase understanding of variations in local weather, precipitation and water resources and how they relate to global climate variation.	TRMM, Seawinds, GPM, Jason-1, Ocean Topography

Enterprise Goals	Science Objectives	Research Focus Areas	Enabling Program/Mission
		Increase understanding of the consequence of land cover and land use change for the sustainability of ecosystems and economic productivity.	LDCM, Landsat-7, Terra, NPP
		Increase understanding of the consequences of climate and sea level changes and increased human activities on coastal regions.	Landsat-7, LDCM, Terra, SeaWifs
	Enable the prediction of future changes in the Earth system.	Increase understanding of the extent that weather forecast duration and reliability can be improved by new space-based observations, data assimilation and modeling.	Seawinds, TRMM, Ocean Topography, Operational satellites
		Increase understanding of the extent that transient climate variations can be understood and predicted	Seawinds, Topex/Poseidon, Aqua, NPP, Jason-1
		Increase understanding of the extent that long-term climate trends can be assessed or predicted.	Improved modeling
		Increase understanding of the extent that future atmospheric chemical impacts on ozone and climate can be predicted.	Improved modeling
		Increase understanding of the extent that future concentrations of carbon dioxide and methane and their impacts on climate can be predicted.	Improved modeling
Expand and accelerate the realization of economic and societal benefits from Earth science, information & technology.	Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private sector decision-makers.	Provide regional decision-makers with scientific and applications products and tools.	RESAC, Federal Partnership (USDA, NOAA, FEMA, EPA), Commercial Partnership Programs

Enterprise Goals	Science Objectives	Research Focus Areas	Enabling Program/Mission
	Stimulate public interest in and understanding of Earth System Science and encourage young scholars to consider careers in science and technology.	Share the excitement of NASA's scientific discoveries and the practical benefits of Earth science to the public in promoting understanding of science and technology in service to the society.	Education/Outreach, New Investigator Program, graduate fellowships, undergraduate curriculum development, professional partnerships, press reports, GLOBE
Develop and adopt advanced technologies to enable mission success and serve national priorities.	Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation.	Successfully develop and infuse technologies that will enable future science measurements, and/or improve performance and reduce the cost of existing measurements. Increase the readiness of technologies under development, retiring risks and advancing them to a maturity level where they can be infused into new missions with shorter development cycles	IIP, tech transfers, commercialization, NMP, ATI, EO-3, GIFTS
		Develop baseline suite of multidisciplinary models and computational tools leading to scalable global climate simulations.	Computational Technologies Program
	Partner with other domestic and international agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction.	Collaborate with other domestic and international agencies in developing and implementing better methods for using remotely sensed observations to support national and international assessments of climate changes and their practical consequences.	Federal Partnership, CEOS, IGOS-P, International Partnership
	Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data.	Develop hardware/software tools to demonstrate high-end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical and biological processes affecting the earth	Computing/Modeling, Computational Technologies Program

Enterprise Goals	**Science Objectives**	**Research Focus Areas**	**Enabling Program/Mission**
Enterprise-Wide Activities that enable achievement of Earth Science strategic goals.	Successfully develop one (1) spacecraft and have ready for launch. Operate instruments on orbiting spacecraft to enable Earth Science research and applications goals and objectives.	Successfully develop and have ready for launch at least one spacecraft. At least 90% of the total on-orbit instrument complement will be operational during their design life.	Satellite Launch
	Successfully disseminate Earth Science data to enable our science research and applications goals and objectives.	Make available ESE acquired data and information on Earth's atmosphere, land and/or oceans to users.	EOSDIS Program
		Increase by 20-30% the total volume of data acquired by and available from NASA for its research programs compared to FY 2002.	
		Maintain satisfactory support for the number of distinct NASA ESE data and information center customers compared to FY 2002.	Airborne Field Campaigns
		Enable production of and distribute scientifically valid data sets from the Aqua mission.	
		Maintain or improve the overall level of ESE data center customer satisfaction as measured by User Working Group surveys.	
	Safely operate airborne platforms to gather remote and *in situ* earth science data for process and calibration/ validation studies.	Support and execute seasonally dependent coordinated research field campaigns within two-weeks of target departure with the aid of airborne and sub-orbital platforms.	

ENABLING PROGRAM/MISSION ACRONYM LIST

ACRIMSat – Active Cavity Radiometer Irradiance Monitor Satellite
AGAGE – Advanced Global Atmospheric Gases Experiment
DMSP – Defense Meteorological Satellite Program
EO-1 – Earth Observing 1
ERS – European Remote-Sensing Satellite
EPA – Environmental Protection Agency
FEMA – Federal Emergency Management Agency
GPS – Global Precipitation Mission
GPS – Global Positioning System
Grace – Gravity Recovery and Climate Experiment
ICESat – Ice, Cloud and Land Elevation Satellite
Landsat – Land Remote-Sensing Satellite
LDCM – Landsat Data Continuity Mission
NOAA – National Oceanic and Atmospheric Administration
NPP – National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Preparatory Program
Quikscat – Quick Scatterometer
RESAC – Regional Science Applications Center
SAGE – Stratospheric Aerosol and Gas Experiment
SAR – Synthetic Aperture Radar
SCIGN – California Integrated GPS Network
SeaWifs – Sea-viewing Wide Field-of-View Sensor
SOLVE – SAGE Ozone Loss and Validation Experiment
SORCE – Solar Radiation and Climate Experiment
SRTM – Shuttle Radar Topography Mission
TOMS – Total Ozone Mapping Mission
TOPEX – Ocean Topography Experiment
TRMM – Tropical Rainfall Measurement Mission
UARS – Upper Atmosphere Research Satellite
USDA – U.S. Department of Agriculture
VLBI/SLR – Very Long Baseline Interferometer/Shuttle Landing Radar

BASIS OF FY 2003 FUNDING REQUIREMENT

EOS PROGRAM

Web Address: http://gaia.hq.nasa.gov/ese_missions/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
Terra	3.3	2.4	--
Aqua (formerly PM-1)	68.5	45.1	4.7
Aura (formerly Chemistry)	99.5	70.4	85.3
Special Spacecraft	113.4	71.0	21.0
EOS Follow-on	55.0	109.6	238.5
Algorithm Development	89.3	83.4	59.7
QuikSCAT	1.1	1.8	--
Landsat-7	1.4	1.7	1.7
Total	431.5	385.4	410.9

* EOS Total life cycle cost data is provided at the end of this section.

DESCRIPTION/JUSTIFICATION

The EOS Program provides a broad range of systematic and survey type observations and measurements to improve our understanding of the Earth system. This improved understanding, combined with improvements in predictive Earth system models, will provide the government and the public with the basis for formulating scientifically well founded environmental and resource management policies.

The EOS Program consists of the following key elements:

(1) Multiple flights to collect measurement sets that contribute to answering the science questions using instruments such as spectrometers, sounders, and radiometers.

(2) Data systems and network facilities to command and control spacecraft and instruments; to process data; and to archive, distribute and manage NASA's Earth science data.

(3) Algorithm development activities to produce the algorithms and software needed to generate the standard data products. These data products will support the Earth System Science research needed to accomplish the ultimate objectives of the Enterprise.

The measurements to be made by these and other future Earth science missions as well as current on-orbit missions provide data products that are used extensively in the Earth science program. These activities are providing an ever-increasing scientific understanding of the global environment and the effects of natural and human sources of change.

EOS PROGRAM ENABLES ANSWERS TO PRIMARY SCIENTIFIC QUESTIONS

The overall goal of the Earth Observing System (EOS) Program is to advance the understanding of the entire Earth system on a global scale by improving our knowledge of the components of the system, the interactions between them, and how the Earth system is changing. The EOS data will be used to study the atmosphere, oceans, cryosphere, biosphere, land surface, and solid Earth; particularly as their interrelationships are manifested in the flow of energy and in the cycling of water and other chemicals through the Earth system.

The objectives of the EOS Program are to develop, launch, and operate remote sensing missions that will provide long-term observations in the area of climate as well as terrestrial and marine ecosystems. The EOS Program will use these observations to provide the supporting information systems necessary to develop a comprehensive understanding of how the Earth functions as a unified system and solve practical problems of interest to society.

The key research topics studied by NASA's ESE fall largely into five categories: variability, forcings, responses, consequences, and prediction. This conceptual approach applies in essence to all research areas of NASA's Earth science program, although it is particularly relevant to the problem of climate change, a major Earth science-related issue facing the countries of the world. The scientific strategy to address this immensely complex problem can be laid out in five steps or fundamental questions, each raising a wide range of cross-disciplinary science problems:

- How is the global Earth system changing? (Variability)
- What are the primary forcings of the Earth system? (Forcing)
- How does the Earth system respond to natural and human-induced changes? (Response)
- What are the consequences of change in the Earth system for human civilization? (Consequence)
- How well can we predict the changes to the Earth system that will take place in the future? (Prediction)

LINKAGES

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Identify and measure primary causes of change in the Earth system; Determine how the Earth system responds to natural and human-induced changes; Identify the consequences of change in the Earth system for human civilization; Enable the prediction of Earth system changes that will take place in the future.

Performance Plan Metrics Supported: Annual Performance Goals as shown in Annual Performance Plan:1A1-1A6, 1B1-1B2, 1C1-1C6, 1D1-**1D3, 1E1-1E5.**

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

The top priority continues to be the existing near-term commitments with the safe and effective implementation of the EOS first series, including the launches of Aqua, Sorce and Icesat in FY 2002.

Also in FY 2002, ESE plans to continue development of NPP and begin/continue formulation activities for a Landsat Data Continuity Mission (LDCM), global precipitation, the observation of global ocean topography and ocean surface winds to succeed TRMM, Jason-1, and SeaWinds on ADEOS II, respectively.

PROGRAM PLANS FOR 2003

In parallel with deploying EOS, NASA ESE is looking ahead to determine the important Earth science questions in the next decade that require NASA's unique capabilities and leadership to be answered. Drawing on existing reports of the National Academy of Sciences and the state of progress in current scientific endeavors, ESE has developed a *Research Strategy for this decade* that articulates a hierarchy of one overarching question, five broad subordinate questions, and twenty-three detailed questions that can and should be tackled over this decade. ESE is in the process of developing roadmaps for each of the detailed questions. Some of those roadmaps may indicate the need for definition of candidate missions.

The opportunity to hand off a required measurement to an operational agency is one of the criteria that were used to identify missions funded in the FY 2003 budget request. Therefore, a high priority in this timeframe is the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Preparatory Program (NPP). NPP will serve to provide continuity with the Terra and Aqua missions as well as a demonstration of instruments for the converged weather satellite program. NASA and the Integrated Program Office (IPO) jointly fund the NPP mission. The IPO consists of representatives from the three agencies participating in NPOESS – NASA, the NOAA, and the Air Force. The follow-on to JASON also falls into this category. Another priority is the Landsat Data Continuity Mission (LDCM) to succeed Landsat-7 as required by the Land remote Sensing Policy Act of

1992 to maintain the continuity of Landsat-type data beyond Landsat-7 into the New Millennium. As with Landsat-7, this mission is being planned in partnership with USGS and the private sector. NASA and USGS plan to implement LDCM as a commercial data purchase and have released a request for proposal from industry for Landsat-type data to meet data continuity requirements. In FY 2003, there will be a pause in the development of other proposed satellites, pending a review of the USGCRP, and its relationship to the new CCRI.

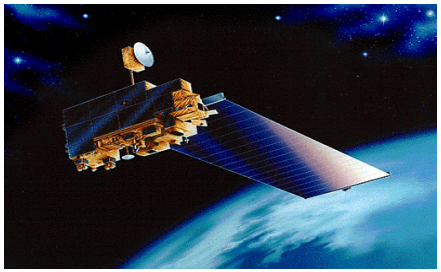
BASIS OF FY 2003 FUNDING REQUIREMENT

TERRA

Web Address: http://terra.nasa.gov/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
TERRA Development ($ in Millions) *	**3.3**	**2.4**	**--**

* TERRA Total life cycle cost data is provided at the end of this section.



DESCRIPTION/JUSTIFICATION

Terra was launched on December 18, 1999 and its aperture doors were opened on February 24, 2000 beginning its science operations. Terra is providing key measurements that are significantly contributing to our understanding of the total Earth system. The instrument complement is obtaining information about the physical and radiative properties of clouds, air-land and air-sea exchanges of energy, carbon, and water as well as measurements of trace gases, and volcanology. Terra Level-1 data products from MODIS and CERES were released 4 months after launch with spacecraft checkout completed by April 2000. Terra collects 200 gigabytes (200,000 megabytes) of data per day over the entire globe. Among the first operational uses of Terra was imagery from the MODIS instrument in support of the U.S. Forest Service to combat the western U.S. forest fires this past summer. The images from MODIS assisted fire fighters in identifying the active locations of the fire(s) itself instead of through smoke-filled images, and allowed them to control the rapidly spreading fires. MODIS imagery was also used by the Geography Department at Dartmouth College in New Hampshire to assist in flood hazard reduction programs. MODIS data also supports geographic information that Dartmouth converts and distributes to disaster relief agencies through the World Wide Web. In FY 2001 Terra Level-2 and above products were released as the first round of product validation efforts completed by instrument science teams. In FY 2001, the Terra spacecraft collected over 99.5 percent of the mission data. All five instruments are operating successfully.

TERRA ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	TERRA APPROACH
How are global ecosystems changing? *What trends in atmospheric constituents and solar radiation are driving global climate?* *What changes are occurring in global land cover and land use, and what are their causes?* *What are the effects of clouds and surface hydrologic processes on Earth's climate?* *How do ecosystems respond to and affect global environmental change and the carbon cycle?* *What are the consequences of land cover and land use change for the sustainability of ecosystems and economic productivity?* *What are the consequences of climate and sea level changes and increased human activities on coastal regions?*	The following instruments are in operation aboard the TERRA spacecraft: The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) obtains high-resolution images of the Earth in 14 different wavelengths of the electromagnetic spectrum, ranging from visible to thermal infrared light. Scientists use ASTER data to create detailed maps of land surface temperature, emissivity, reflectance, and elevation. The Multi-Angle Imaging Spectro-Radiometer (MISR) views the Earth with cameras pointed at nine different angles. In addition to improving our understanding of the fate of sunlight in the Earth's environment, MISR data can distinguish different types of clouds, aerosol particles, and surfaces. The Moderate-resolution Imaging Spectroradiometer (MODIS) sees every point on our world every 1-2 days in 36 discrete spectral bands. Consequently, MODIS greatly improves upon the heritage of the NOAA Advanced Very High Resolution Radiometer (AVHRR) and tracks a wider array of the earth's vital signs than any other Terra sensor. For instance, the sensor measures the percent of the planet's surface that is covered by clouds almost every day. This wide spatial coverage enables MODIS, together with MISR and CERES, to determine the impact of clouds and aerosols on the Earth's energy budget. The Measurement of Pollution in the Troposphere (MOPITT) is an instrument designed to enhance our knowledge of the lower atmosphere and to particularly observe how it interacts with the land and ocean biospheres. There are two identical CERES instruments aboard Terra that measure the Earth's total radiation budget and provide cloud property estimates that enable scientists to assess clouds' roles in radiative fluxes from the surface to the top of the atmosphere.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Identify and measure primary causes of change in the Earth system; Determine how the Earth system responds to natural and human-induced changes; Identify the consequences of change in the Earth system for human civilization; Enable the prediction of Earth system changes that will take place in the future.

Performance Plan Metrics Supported: See Annual Performance Goals 1A3, 1B1, 1B2, 1C1, 1C2, 1D2, 1D3 as described in above science question section.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-FY03 Change	Comment
Spacecraft Complete	3/99	3/99	3/98		
Del Flight	8/97	8/97	2/97		
Start Observatory I&T	3/96	3/96	3/97		
Del Observatory	3/99	3/99	3/98		
Launch	12/99	12/99	6/98		Successfully launched 12/18/99

Lead Center: GSFC

Other Centers: JPL and LARC (instrument development), KSC (Launch vehicle)

Subsystem	Builder
Spacecraft	Lockheed-Martin, Valley Forge, PA

Instruments	Builder
Moderate Resolution Imaging Spectro Radiometer (MODIS)	Raytheon (SBRS)
Multi-Angle Imaging Spectro-Radiometer (MISR)	JPL
Clouds and the Earth's Radiant Energy System (CERES)	LARC/TRW
Measurements of Pollution in the Troposphere (MOPPITT)	Canadian Space Agency
Adv Spaceborne Therm Emis & Reflect Radiometer (ASTER)	Japan/JAROS

Launch Vehicle: Atlas IIAS

Tracking/Communications: TDRS/Ground Network

Data Handling: EOSDIS

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Spacecraft operations are nominal.

PROGRAM PLANS FOR FY 2003

Continue nominal operations budgeted under Earth Science Operations.

TERRA LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	**1,142.4**									**1,142.4**
FY03 President's Budget	**1,387.5**	**3.3**	**2.4**							**1,393.2**
Development	**1,220.8**	**3.3**	**2.4**							**1,226.5**
Launch Vehicle	**166.7**									**166.7**
FTEs (number)		(1)								

BASIS OF FY 2003 FUNDING REQUIREMENT

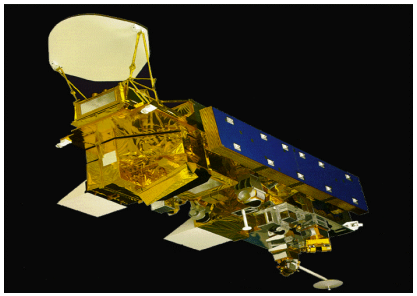
EOS PROGRAM - PROJECTS IN IMPLEMENTATION

AQUA

Web Address: http://eos-pm.gsfc.nasa.gov/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
AQUA Development ($ in Millions) *	**68.5**	**45.1**	**4.7**

* AQUA Total life cycle cost data is provided at the end of this section.



DESCRIPTION/JUSTIFICATION

The Aqua spacecraft payload will consist of a suite of passive microwave radiometers, infrared radiometers, high spectral resolution infrared sounding and infrared imaging instruments that will be used to help improve numerical weather prediction and understanding of the Earth's climate. Specifically these instruments will provide measurements of:

1. Atmospheric temperature and humidity profiles, clouds, aerosols, and radiative balance
2. Measurements of the extent of terrestrial snow and ice
3. Sea-surface temperature and ocean productivity.

AQUA ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	AQUA APPROACH
How are global precipitation, evaporation, and the cycling of water changing? How is the global ocean circulation varying on inter-annual, decadal, and longer time scales? How are global ecosystems changing? What are the effects of clouds and surface hydrologic processes on Earth's climate? How do ecosystems respond to and affect global environmental change and the carbon cycle?	The instruments carried on Aqua will have the following technical characteristics: • Advanced Infrared Sounder (AIRS) - A grating array spectrometer infrared sounder that will measure tropospheric and stratospheric temperature, day-and-night sides, globally, every 2 days; • Advanced Microwave Scanning Radiometer (AMSR-E) provided by Japan- A scanning passive microwave radiometer which will provide all-weather, day/night, global observations of a variety of surface and atmospheric variables (precipitation, water vapor, temperature, snow and ice, soil moisture); • Advanced Microwave Sounding Unit (AMSU-A) - A microwave sounding radiometer that provides atmospheric temperature measurements, plus a cloud-filtering capability for tropospheric observations (intricately coupled with AIRS); • Clouds and the Earth's Radiant Energy System (CERES) - Two broadband scanning radiometers providing radiant flux at the top of the atmosphere; • Humidity Sounder for Brazil (HSB) provided by Brazil - A four-channel microwave sounding radiometer providing (with AIRS and AMSU) humidity profiles under overcast conditions. • Moderate Resolution Imaging Spectroradiometer (MODIS) - An imaging spectroradiometer designed to measure biological and physical processes on a global basis every 1 to 2 days; providing land and ocean temperatures, ocean color, Earth's vegetation and land surface cover, and cloud cover and properties.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Determine how the Earth system responds to natural and human induced changes.

Performance Plan Metrics Supported: See Annual Performance Goals 1A1, 1A2, 1A3, 1C1, 1C2 as described in scientific question section above.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-FY03 Change	Comment
Preliminary Design Review	April 1997	April 1997	April 1997		
Critical Design Review	June 1998	June 1998	April 1998		
Spacecraft Complete	October 2000	October 2000	October 2000		
Deliver Flight Instruments	January 2000	January 2000	September 1999		Due to Spacecraft problems, instrument delivery delayed
Start Observatory Integration &Test	June 1999	June 1999	June 1999		
Launch	NET March 2002	NET June 2001	December 2000		Launch delay due to technical issues related to spacecraft (array electronics/solid state recorder) delayed observatory I&T

Lead Center: GSFC	**Other Centers:** JPL, LaRC, KSC	**Interdependencies:** Japan, Brazil, EOS Aura Mission (Common spacecraft 2nd build after Aqua)
Subsystem	**Builder**	
Spacecraft	TRW, Redondo Beach, CA	
Instruments	**Builder**	
Moderate Resolution Imaging Spectro Radiometer (MODIS)	Raytheon (SBRS)	
Atmospheric Infrared Sounder (AIRS)	JPL/LMIRIS	
Cloud & the Earth's Radiant Energy System (CERES)	LaRC/TRW	
Advanced Microwave Sounding Unit (AMSU-A)	Aerojet	
Advanced Microwave Scanning Radiometer (AMSR-E)	NASDA/MELCO	
Humidity Sounder Brazil (HSB)	Brazil INPE/MMS	
Launch Vehicle: Delta II 7920	**Tracking/Communications:** TDRSS/Ground Network	**Data Handling:** EOS Data Information System

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

In FY2001, observatory integration and test continued, culminating in a successful thermal vacuum test ending in early October 2001. Currently the spacecraft and instrument combination is going through its final series of tests prior to shipment to the Western Test Range (Vandenburg Air Force Base) for launch. Launch is planned for no earlier than (NET) March 2002.

PROGRAM PLANS FOR FY 2003

After a 120 day on orbit checkout, the spacecraft will be turned over to operations. The balance of FY 2002 and FY 2003 is expected to be normal operations with the return of science data.

AQUA LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle (Does not include Launch Vehicle)	926.3	20.4								946.7
FY03 President's Budge	829.3	68.5	45.1	4.7	4.6	0.1	0.1			952.4
Development	773.7	65.3	45.1	4.7	4.6	0.1	0.1			893.6
Launch Vehi	55.6	3.2								58.8
FTEs (number)		(39)	(6)							

BASIS OF FY 2003 FUNDING REQUIREMENT

EOS PROGRAM - PROJECTS IN IMPLEMENTATION

AURA

Web Address: http://eos-chem.gsfc.nasa.gov/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
AURA Development ($ in Millions) *	**99.5**	**70.4**	**85.3**

* AURA Total life cycle cost data is provided at the end of this section.

DESCRIPTION/JUSTIFICATION

The Aura mission will study the chemistry and dynamics of the Earth's atmosphere with emphasis on the troposphere and lower stratosphere (altitudes up to 20 km). The mission will measure ozone, aerosols, and several key atmospheric constituents that play an important role in atmospheric chemistry, air quality, and climate. This mission will help in understanding the chemical and pollutant transport phenomena that are essential ingredients in evaluating the environmental policies and international agreements on chlorofluorocarbon (CFC) phase out.

The Aura project will launch four instruments on the EOS Common Spacecraft into a 705km, 98.2-degree inclination, polar sun-synchronous orbit. The spacecraft will have an equatorial crossing time (ascending node) of 1:45pm.

AURA ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	AURA APPROACH
How is stratospheric ozone changing, as the abundance of ozone-destroying chemicals decrease and new substitutes increase?	The instruments carried on AURA will have the following technical characteristics: • High Resolution Dynamic Limb Sounder (HIRDLS) jointly built by NASA and the United Kingdom- is an infrared limb-scanning radiometer designed to sound the

How do stratospheric trace constituents respond to change in climate and atmospheric composition? What are the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality?	upper troposphere, stratosphere and mesosphere. • Microwave Limb Sounder (MLS) - ranging from 118 GHz to 2.5THz frequency, is designed to measure the stratospheric temperature and numerous chemical species. • Tropospheric Emission Spectrometer (TES)- a high-resolution infrared imaging Fourier transform spectrometer that observes in the limb and nadir. • Ozone Monitoring Instrument (OMI) provided by the Netherlands Space Agency and the Finnish Meteorological Institute - is an ultraviolet and visible grating spectrometer providing global mapping of ozone and other trace gases.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Determine how the Earth system responds to natural and human induced changes.

Performance Plan Metrics Supported: See Annual Performance Goals 1A4, 1C4, 1C6 as described in scientific question section above.

Key Milestones:	**FY 2003 DATE**	**FY 2002 DATE**	**BASELINE DATE**	**CHANGE (FY02-FY03)**	**COMMENT**
Preliminary Design Review	October 1999	October 1999	March 1998		
Critical Design Review	August 2000	August 2000	August 2000		
Spacecraft Integration &Test	August 2001	August 2001	June 2001		
Instrument Delivery	October 2002	May 2002	June 2001	+ 5 Months	Inst. Problems causing later delivery, reduced slack
Launch	NET Jan 2004	July 2003	December 2002	+ 6 Months	Launch delay due to instrument problems/delays; shared resources (staffing & GFE) with Aqua and longer test times for Aura based on Aqua experience.

Lead Center: GSFC	**Other Centers:** JPL (Instrument development), KSC (Launch vehicle)	**Interdependencies:** United Kingdom, Netherlands, EOS Aqua mission (1st build of EOS common spacecraft)
Subsystem Spacecraft:	**Builder** TRW, Redondo Beach, CA	
Instruments Microwave Limb Sounder (MLS) Tropospheric Emission Spectrometer (TES) High Resolution Dynamics Limb Sounder (HIRDLS) Ozone Measuring Instrument (OMI)	**Builder** JPL JPL LMSS/Oxford/RAL, United Kingdom TNO/TPD, Fokker/VTT, Netherlands	
Launch Vehicle: Delta II 7920	**Tracking/Communications**: TDRSS/Ground Network	**Data Handling:** EOS Data Information System

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

During FY 2001, the remaining technology developments required for the EOS Aura Instruments were demonstrated. Nearly all of the flight subsystem hardware was completed and delivered to system-level Integration and Test (I&T). Progress on the spacecraft bus was also very successful. The Aura and Aqua missions share a common spacecraft contractor. As a result of Aqua technical issues, the Aqua delays have impacted the integration schedule of Aura. Hardware technical problems that were discovered during I&T of the Aqua spacecraft are being addressed for Aura as well. In FY 2002, integration of the spacecraft bus will be completed, as will integration, test, and calibration of all of the instruments.

PROJECT PLANS FOR FY 2003

Integration of the instruments onto the observatory will occur in late FY 2002 based on lessons learned from Aqua spacecraft. This will result in extended test durations. Observatory level testing will be conducted in FY 2003, with the launch of Aura planned for January 2004. Funding requirements for the launch readiness delay from July 2003 to January 2004 are being assessed. A major factor in this assessment is the successful completion of Aqua development and its launch, which is currently, scheduled NET March 2002.

AURA LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	Y 2005	FY 2006	FY 2007	Total
Initial Baseline (lifecycle) (Does not include Launch Vehicle)	561.8	145.8							707.6
FY03 President's Budget	451.7	99.5	70.4	85.3	0.1				707.0
Development	451.6	85.6	42.0	70.0	0.1				649.3
Launch Vehicle	0.1	13.9	28.4	15.3					57.7
FTEs (number)		(40)	(45)	(40)	(8)				

Note: Funding requirments for the launch readiness delay from July 2003 to January 2004 are being assessed (starting in FY 2003).

BASIS OF FY 2003 FUNDING REQUIREMENT

PROJECT DATA-SPECIAL

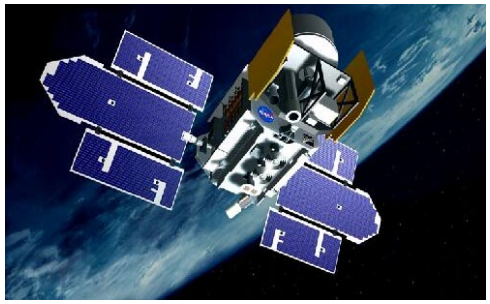
The Special spacecraft are designed to study atmospheric aerosols, ocean circulation, ice-sheet mass balance, cloud physics, atmospheric radiation properties, and solar irradiance

SPECIAL: ICESat

Web Address: http://icesat.gsfc.nasa.gov/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
ICESat Development ($ in Millions) *	**53.3**	**21.6**	**--**

***** ICESat Total life cycle cost data is provided at the end of this section.



DESCRIPTION/JUSTIFICATION

The Ice, Clouds and land Elevation Satellite (ICESat) Project provides a subset of the EOS measurements, primarily land ice and sea ice products, for which an orbit is required that maximizes polar coverage over the ice sheets.

ICESat ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	ICESat APPROACH
What changes are occurring in the mass of the Earth's ice cover?	The primary objective of the ICESat mission is to measure ice sheet height and volume change for long-term climate variability studies, providing a 3-year data set of ice sheet topography. This will be achieved via a laser altimetry instrument, Geoscience Laser Altimeter System (GLAS), an Nd:YAG laser with 1064 and 532 nm output. The instrument will be launched into a 600 km, 94° inclination orbit.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing.

Performance Plan Metrics Supported: See Annual Performance Goal 1A5 as described in scientific question section above.

Key Milestones:	FY 2003 DATE	FY 2002 DATE	BASELINE DATE	CHANGE (FY02-	COMMENT
Instrument Preliminary Design Review	June 1998	June 1998	June 1998		
Instrument Critical Design Review	March 1999	March 1999	March 1999		
Spacecraft Complete	June 2001	October 2000	October 2001	+8 months	Delayed interface definition and risk reduction
Instrument Delivery	TBD	February 2001	October 2001	TBD	Optical stability and rework
Algorithm (V2)	April 2001	April 2001	January 2002		
Observatory Integration &Test	TBD	June 2001	May 2002	TBD	Delayed instrument delivery
Launch	NET March 2002	December 2001	January 2002	+3	Delayed instrument delivery

Lead Center: GSFC

Other Centers: KSC (Launch vehicle), JPL GPS Receiver

Interdependencies: EOS SORCE Project/University of Colorado at Boulder, Laboratory for Atmospheric and Space Physics (LASP). LASP is performing mission ops for both ICESAT and SORCE.

Subsystem	Builder
Spacecraft	Ball Aerospace
Global Positioning System (GPS) Receiver	JPL

Instruments	Builder
Geoscience Laser Altimeter System (GLAS)	GSFC/In-house

Launch Vehicle: Delta 7320

Tracking/Communications: Ground Network

Data Handling: EOS Data Information System/LASP

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

The spacecraft was fully qualified in the summer of 2001. The Mission Operations Center and Instrument Support Facility were also completed. The GLAS instrument experienced a laser failure and instrument technical problems continue to erode the schedule. The spacecraft bus is flight qualified and awaiting GLAS delivery. The schedule is being re-evaluated under new management. Planned activities for FY 2002 include delivery of the GLAS instrument, integration and test with the spacecraft. Funding requirements for a launch readiness delay beyond March 2002 are being assessed.

PROJECT PLANS FOR FY 2003

Generation of data products will begin in late FY 2003 and continue for 3 years.

ICESat LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	Y 2002	Y 2003	Y 2004	Y 2005	Y 2006	Y 2007	BTC	Total
Initial Baseline (lifecycle)	**127.5**	**37.6**								**165.1**
FY03 President's Budget	**139.6**	**53.3**	**21.6**							**214.5**
Development	**123.0**	**29.2**	**14.7**							166.9
Launch Vehicle	**16.6**	**24.1**	**6.9**							47.6
FTEs (number)		(51)	(15)							

BASIS OF FY 2003 FUNDING REQUIREMENT

SPECIAL: SeaWinds

Web Address: http://gaia.hq.nasa.gov/ese_missions

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
SeaWinds Development ($ in Millions) *	**4.1**	**4.5**	**2.2**

* SeaWinds Total life cycle cost data is provided at the end of this section.

DESCRIPTION/JUSTIFICATION

The Sea Winds mission provides a set of time critical series of global marine wind vector measurements. This mission is in partnership with the National Space Development Agency (NASDA) of Japan for Earth remote sensing. The first instrument of the series, NSCAT, was launched in August 1996 on NASDA's ADEOS spacecraft. The first ADEOS mission was terminated in June 1997 due to a solar array failure. The Japanese will provide the Advanced Earth Observing System II (ADEOS II) spacecraft for the Seawinds instrument to measure ocean surface wind velocity as a follow-on to the NASA Scatterometer instrument on ADEOS-I and the Seawinds instrument on QuikSCAT.

SeaWinds ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	SeaWinds APPROACH
How is the global ocean circulation varying on interannual, decadal, and longer time scales?	SeaWinds has a Ku Band microwave radar with a rotating antenna used to determine radar scattering cross section globally and to infer wind velocity (speed and direction) over 90% of the ice-free ocean surface every two days with a resolution of 25km.
What are the effects of clouds and surface hydrologic processes on Earth's climate?	SeaWinds will acquire all-weather, high-resolution measurements of near-surface winds over the global oceans. It will determine atmospheric forcing, ocean response and air-sea interaction mechanisms on various spatial and temporal scales as well as combine wind data with measurements from scientific instruments in other disciplines to understand mechanisms of global climate change and weather patterns.
How are variations in local weather, precipitation, and water resources related to global climate variation?	SeaWinds will also improve weather forecasts near coastlines by using wind data in numerical weather- and wave-prediction models that will also improve storm warning and monitoring
How can weather forecast duration and	

reliability be improved by new space-based observations, data assimilation, and modeling? How well can transient climate variations be understood and predicted?	

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Determine how the Earth system responds to natural and human-induced changes; Identify the consequences of changes in the Earth system for human civilization; Enable the prediction of Earth system changes that will take place in the future.

Performance Plan Metrics Supported: See Annual Performance Goals 1A2, 1C1, 1D1, 1E1 as described in scientific question section above.

Key Milestones:	FY 2003 BUDGET DATE	FY 2002 BUDGET DATE	BASELINE DATE	CHANGE (FY02-FY03)	COMMENT
Preliminary Design Review (PDR)	May 1995	May 1995	May 1995		
Critical Design Review (CDR)	March 1999	March 1999	March 1998		
Instrument Delivery	March 1999	March 1999	March 1998		
Del SC I/V Site	September 2001	TBD	Pre ship rev 3/99		
Launch	NET November 2002	TBD	August 1999		Launch delays due to ADEOS II spacecraft delays by NASDA (Japan)

Lead Center: JPL	**Other Centers:**	**Interdependencies:** NASDA, Japan
Subsystem	**Builder**	
Spacecraft: ADEOS II	Japan	
Instruments	**Builder**	
SeaWinds	JPL	

Launch Vehicle: H-IIA **Tracking/Communications:** Japanese and NASA ground network **Data Handling:** JPL and EOSDIS

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

The SeaWinds protoflight model was delivered to Tsukuba, Japan in March 1999 for a launch on the ADEOS II spacecraft by a NASDA H-IIA rocket from Tanegashima, Japan. The spacecraft was shipped to the launch site (Tanegashima) during September 2001. It is currently going through post-shipment tests. After the completion of the tests, the spacecraft will go into storage until the beginning of the launch campaign. This budget assumes a NET July 2002 launch. NASA has recently been advised by NASDA that the Japanese Space Activities Commission (SAC) want to have 3 successful H-IIA rocket launches prior to the ADEOS-II launch. This sets the ADEOS-II launch to take place no earlier than November 2002. The project is currently assessing the impact of this delay on future operational requirements.

PROJECT PLANS FOR FY 2003

Generation of data products will begin in late CY 2002 and continue for 5 years.

SeaWinds LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	135.0									135.0
FY03 President's Budget	134.9	4.1	4.5	2.2	1.0	0.5	0.2	0.1		147.5
Development	134.9	4.1	4.5							143.5
Mission Operatins				2.2	1.0	0.5	0.2	0.1		4.0
FTEs (number)										

BASIS OF FY 2003 FUNDING REQUIREMENT

JASON-1

Web Address: http://www.jpl.nasa.gov/missions/current/jason1.html

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
JASON-1 Development *	**7.8**	**1.5**	**--**

* JASON-1 Total life cycle cost data is provided at the end of this section.

DESCRIPTION/JUSTIFICATION

Jason-1 is a Radar Altimetry mission which is a follow-on to the TOPEX/Poseidon. Jason-1 is a cooperative joint mission with the French Space Agency (CNES), with data provided to NOAA for operational purposes. Jason-1 was successfully launched on a Delta II 7920 on December 7, 2001.

JASON-1 ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	JASON-1 APPROACH
How is the global ocean circulation varying on interrannual, decadal, and longer time scales? How are variations in local weather, precipitation, and water resources related to global climate variation?	Jason-1 is an oceanography mission to monitor global ocean circulation. It will also study the ties between the oceans and atmosphere, improve global climate forecasts and predictions, and monitor events such as El Niño conditions and ocean eddies. Jason-1 has been designed to directly measure climate change through very precise millimeter-per-year measurements of global sea-level changes. The Jason-1 satellite, its altimeter instrument and a position-tracking antenna were built in France. The spacecraft also carries a radiometer instrument to measure water vapor, a Global Positioning System receiver and a laser retroreflector array built in the United States.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing. Identify the consequences of changes in the Earth system for human civilization.

Performance Plan Metrics Supported: See Annual Performance Goals 1A2, 1D1 as described in scientific question section above.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-FY03 Change	Comment
Launch	December 2001	NET June 2001	December 1999	6	French Space Agency (CNES) delays; Successfully launched 12/7/01 at VAFB

Lead Center: JPL

Other Centers: KSC (launch vehicle), France-CNES (Spacecraft)

Subsystem	Builder
Spacecraft	French Space Agency (CNES)

Instruments	Builder
Jason-1 Microwave Radiometer (JMR) Engineering Model	TRW
JMR Flight Model	TRW
JMR Reflectors	Composite Optics Inc (COI)
TRSR-Global Positioning Sys	Spectrum Asto Inc (SAI

Launch Vehicle: Delta 7920

Tracking/Communications: JPL

Data Handling: Physical Oceanography Distributed Active Archive Center (PODAAC)

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Spacecraft operations are nominal.

PROGRAM PLANS FOR FY 2003

Continue operations budgeted under EOSDIS.

JASON LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	Y 2002	Y 2003	Y 2004	Y 2005	Y 2006	Y 2007	BTC	Total
Initial Baseline (lifecycle)	**43.3**									**43.3**
FY03 President's Budget	**69.7**	**7.8**	**1.5**							**79.0**
Development	**35.5**	**7.8**	**1.5**							44.8
MO	**34.2**									34.2
FTEs (number)										

BASIS OF FY 2003 FUNDING REQUIREMENT

SPECIAL: SORCE

Web Address: http://lasp.colorado.edu/sorce/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
SORCE Development *	**24.1**	**18.7**	**4.0**

* SORCE Total life cycle cost data is provided at the end of this section.

DESCRIPTION/JUSTIFICATION

The SORCE Mission replaces the EOS-Solar Stellar Irradiance Comparison Experiment (SOLSTICE) and Total Solar Irradiance Mission (TSIM). These missions were combined as a result of an accommodation study, which recognized both the scientific and financial benefits of combining SOLSTICE and TSIM. The principal goal of the SORCE Mission is to measure both total and spectrally resolved solar irradiance.

The Total Solar Irradiance (TSI) measurement is a continuation of the first space-borne measurements begun by Nimbus 7 in 1978. Currently, three spacecraft are sustaining the TSI database, ACRIMSAT, the Upper Atmosphere Research Satellite (UARS) and the Solar Heliosphere Observer SOHO). Continued and uninterrupted population and monitoring of the TSI data set will provide insight into long-term climate changes. These measurements will continue the total solar irradiance and spectrally resolved solar irradiance measurements being made from UARS since 1991, as well as earlier missions for TSI measurements and will add additional capability. They will be used to further understand the effects of solar variability on long-term global climate change and influences on the stratospheric ozone layer. Additionally, the spectral measurements in the 200-300 nm and 1500 nm spectral regions will fulfill the NPOESS operational requirements as part of a tri-agency partnership with NASA, NOAA, and DoD.

SORCE ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	SORCE APPROACH
What trends in atmospheric constituents and solar radiation are driving global climate?	The SORCE Mission will consist of four instruments to provide solar and stellar irradiance measurements: • Total Irradiance Monitor (TIM) – The TIM is an active cavity radiometer and will provide the TSI measurements. TIM consists of four independent radiometer channels, which provide duty cycle stability and redundancy. TSI data will consist of multiple samples taken each orbit providing 15 measurements per day

	• with an absolute accuracy of 150 parts/million (relative accuracy of 10 parts/million per year). • XUV Photometer System (XPS) – The XPS will provide measurements of the extreme ultraviolet bandwidth (1-31 nm) every orbit. Detectors consist of 12 filtered individual Si photodiodes with six unique, three redundant, and three bare channels. XPS has a spectral resolution of 5 to 10 nm and an absolute accuracy of 20 percent (relative accuracy of 10 percent/year). • Solar Stellar Irradiance Comparison Experiment (SOLSTICE) – SOLSTICE is a scanning grating spectrometer capable of both solar and stellar observations. It consists of two independent and redundant units. Each unit is capable of measuring a FUV bandwidth (115 – 175 nm) and a MUV bandwidth (175 – 300 nm). Solar and stellar observations will be made every orbit with a spectral resolution of 0.1 to 0.2 nm and an absolute accuracy of 1.5 to 5 percent (relative accuracy of 0.5 percent). • Spectral Irradiance Monitor (SIM) – SIM is a scanning prism spectrometer providing coverage of a wide bandwidth from 200 -–2000 nm. It consists of two redundant channels within one unit. The primary detector is an electrical substitution radiometer. Measurements over the visible and near IR solar spectrum will be made every orbit with a spectral resolution 0.2 to 30 nm and an absolute accuracy of 1500 parts/million (relative accuracy of 100 parts/million per year).

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Identify and measure primary causes of change in the Earth system.

Performance Plan Metrics Supported: See Annual Performance Goals 1B1 as described in scientific question section above.

Key Milestones:	FY 2003 DATE	FY 2002 DATE	BASELINE DATE	CHANGE (FY02-FY03)	COMMENT
Preliminary Design Review	May 1999	May 1999	May 1999		
Critical Design Review	November 2000	November 2000	October 2000		
Spacecraft Complete	November 2001	October 2001	October 2001	+ 1 month	Spacecraft Bus delay due to OSC avionics box fabrication & testing
Last Instrument Delivery	November 2001	October 2001	October 2001	+ 1 months	Result of Spacecraft Bus delay
Integration &Test Complete	May 2002	May 2002	May 2002		
Deliver Spacecraft to KSC	June 2002	June 2002	June 200		
Launch	July 2002	July 2002	July 2002		

Lead Center: GSFC	**Other Centers:** KSC (Launch vehicle)	**Interdependencies:** University of Colorado at Boulder, Laboratory for Atmospheric and Space Physics (LASP). LASP is performing mission ops for both SORCE and ICESAT.
Subsystem Spacecraft:	**Builder** Orbital Sciences Corp.	
Instruments SOLSTICE Spectral Irradiance Monitor (SIM) XUV Photometer System (XPS) Total Irradiance Monitor (TIM)	**Builder** LASP LASP LASP LASP	**Principal Investigator:** Gary Rottman
Spacecraft	Orbital	
Launch Vehicle: Pegasus XL	**Tracking/Communications**: Ground Network	**Data Handling**: Laboratory for Atmospheric and Space Physics

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

The SORCE Team successfully completed the Mission Operations Review in April 2001. The SORCE Instruments have completed their final instrument assembly. Critical activities for FY 2002 include completion of observatory integration and test with launch scheduled for July 2002.

PROJECT PLANS FOR FY 2003

Generation of data products will begin in late CY 2002 and continue for 5 years.

SORCE LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	52.8	23.0	16.7	4.0	2.0	2.0	2.0	1.8		104.3
FY03 President's Budget	49.4	24.1	18.7	4.0	2.0	2.0	2.0	1.8		104.0
Development	45.9	14.2	9.2	1.5	0.4	0.4	0.4	0.4		72.4
Mission Operations	0.1	0.2	1.3	2.5	1.6	1.6	1.6	1.4		10.3
Launch Vehicle	3.4	9.7	8.2							21.3
FTEs (number)	6	5	1	1	1	1	1	1		

BASIS OF FY 2003 FUNDING REQUIREMENT

ACRIM

Web Address: http://acrim.jpl.nasa.gov/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
ACRIM Development *	**1.6**	**1.5**	**1.5**

* ACRIM Total life cycle cost data is provided at the end of this section.

DESCRIPTION/JUSTIFICATION

The EOS ACRIMSAT was launched December 20, 1999, and continues the measurement of Total Solar Irradiance (TSI) begun by the ACRIM instruments on the Solar Maximum Mission and Upper Atmospheric Research Satellite (UARS).

ACRIM ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	ACRIM APPROACH
What trends in atmospheric constituents and solar radiation are driving global climate?	The Active Cavity Radiometer Irradiance Monitor III instrument is measuring total solar irradiance from the sun. The instrument, third in a series of long-term solar-monitoring tools built for NASA by the Jet Propulsion Laboratory, will continue to extend the data set first created by ACRIM I, which was launched in 1980 on the Solar Maximum Mission (SMM) spacecraft. ACRIM II followed on the Upper Atmosphere Research Satellite (UARS) in 1991.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Identify and measure primary causes of change in the Earth system.

Performance Plan Metrics Supported: See Annual Performance Goals 1B1 as described in scientific question section above.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-FY03 Change	Comment
Launch	December 1999	December 1999	October 1999		Successfully launched December 20, 1999

Lead Center: JPL

Other Centers: KSC (Launch vehicle)

Subsystem

Builder

Instruments
ACRIM Instrument

Builder
JPL – In-house

Launch Vehicle: Taurus

Tracking/Communications: Table Mountain Observatory (TMO); JPL

Data Handling: EOSDIS

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Spacecraft operations are nominal.

PROGRAM PLANS FOR FY 2003

Continue operations.

ACRIM LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	19.9	3.8								23.7
FY03 President's Budget	29.6	1.6	1.5	1.5	1.3	0.5				36.0
Development	20.5	0.7	0.6	0.6	0.5	0.1				23.0
Mission Operations	1.1	0.9	0.9	0.9	0.8	0.4				5.0
Launch Vehicle	8.0									8.0
FTEs (number)										

BASIS OF FY 2003 FUNDING REQUIREMENT

SAGE

Web Address: http://www-sage3.larc.nasa.gov/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
SAGE Development *	**3.0**	**1.3**	**0.1**

* SAGE Total life cycle cost data is provided at the end of this section.

DESCRIPTION/JUSTIFICATION

The Meteor/SAGE-III was successfully launched on December 10, 2001. Scheduled for a three-year mission, the Meteor/SAGE-III is a joint partnership between NASA and the Russian Aviation and Space Agency. A calibration/validation campaign is tentatively scheduled for FY 2003. A second SAGE-III instrument is scheduled to fly aboard the International Space Station in FY 2005.

SAGE ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION (Annual Performance Goal):	SAGE APPROACH
How is stratospheric ozone changing, as the abundance of ozone-destroying chemicals decrease and new substitutes increase? What trends in atmospheric constituents and solar radiation are driving global climate? How do stratospheric trace constituents respond to change in climate and atmospheric composition?	The Sage-III instruments were manufactured for long-term monitoring of ozone and aerosols. Sage III takes advantage of both solar and lunar osculation to measure vertical profiles of aerosols, ozone, and other gaseous constituents of the atmosphere and will continue a more than 25-year record of calibrated ozone profile data.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Identify and measure primary causes of change in the Earth system; Determine how the Earth system responds to natural and human-induced changes.

Performance Plan Metrics Supported: See Annual Performance Goals 1A4, 1B1,1C4 as described in scientific question section above.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-FY03 Change	Comment
Instrument Delivered	September 1998	September 1998	December 1997		Russian delays
Algorithms (V2)	November 2001	December 2000	December 1997		Commensurate with delay in launch
Launch	December 2001	June 2001	December 1998		Successfully launched on12/10/01 in Baikonur, Russia

Lead Center: LARC

Other Centers: GSFC, Russia LV

Instruments	Builder
SAGE Instrument	Ball

Launch Vehicle: Zenit 2

Tracking/Communications: Russian and US ground Network

Data handling: EOSDIS

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Spacecraft is operating nominally.

PROGRAM PLANS FOR FY 2003

Continue operations budgeted under EOSDIS.

SAGE LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	67.6	0.0								67.6
FY03 President's Budget	67.0	3.0	1.3	0.1	0.1	0.1	0.1	0.1		71.8
Development	67.0	3.0	1.3	0.1	0.1	0.1	0.1	0.1		71.8
FTEs (number)										

Outyear funds are for storage costsof SAGE Flight of Opportunity

BASIS OF FY 2003 FUNDING REQUIREMENT

SCISAT ELV AND OTHER

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
SCISAT ELV Development	**8.9**	**9.1**	**--**
HQ Institutional Support	**10.6**	**12.8**	**13.2**

DESCRIPTION/JUSTIFICATION

As a result of an Agency level Space Station Memorandum of Understanding (MOU) signed between NASA and the Canadian Space Agency (CSA) in May 1994, the ESE committed to a joint science program where NASA would provide a launch vehicle for the Canadian SciSAT mission in a separate MOU signed October 2000. The Kennedy Space Center negotiated the launch vehicle contract in FY 2000. The launch date was slipped from June 2002 to December 2002 after a detailed review by CSA to mitigate schedule risk.

HQ institutional support funds administrative activity that supports the operation of the Earth Science Enterprise including contract administration requirements.

BASIS OF FY 2003 FUNDING REQUIREMENT

EOS PROGRAM

EOS FOLLOW-ON

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
EOS Follow-on	**55.0**	**109.6**	**238.5**

DESCRIPTION/JUSTIFICATION

The next generation of EOS missions will provide new technology and space systems to meet the scientific needs for the NASA Earth science projects. NASA ESE has identified a mission architecture over the mid-term that will help achieve the specific scientific goals using a combination of systematic and exploratory missions. The new missions selected will capitalize on our investments in advanced technologies to reduce lifecycle time/cost and relate to longer-term scientific questions and practical applications. The approach to mission selection and implementation will assure maturity of key and essential technology during mission definition and formulation for both exploratory and systematic missions (i.e. no missions will go into implementation until key technologies are ready). Missions with firm plans for a hand-off to an operational agency will be continued in FY 2003. No other missions will be started or continued, until a review of the USGCRP , and its relationship to the new CCRI, is complete.

The first set of systematic missions has been under formulation and study during the past year. Therefore, detailed life cycle cost data is not available at this time.

These missions are:

PROJECT DATA- OCEAN SURFACE TOPOGRAPHY

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
Ocean Surface Topography Mission	**0.3**	**9.1**	**32.4**

DESCRIPTION/JUSTIFICATION

The Ocean Surface Topography Mission (OSTM) will provide continuity of ocean topography measurements beyond Topex/Poseidon and Jason-1, for determining ocean circulation, climate change and sea level rise. This mission is currently in formulation and is being led by JPL.

The objective of the OSTM is to continue the measurement made by Topex/Poseidon and Jason-1 that is essential to the understanding of ocean circulation and its effects on climate. To observe and understand how this climatic state will evolve in the next decade is vital to the understanding of long-term climate change. This mission will also provide a bridge to an operational mission to enable the continuation of multi-decadal ocean topography measurements for ocean circulation and climate studies.

The OSTM will use the same measurement approach used by the Jason-1 mission. The OSTM will be developed and operated as a four party international collaboration among NASA, NOAA, CNES, and European Meteorological Satellite (EUMETSAT), with the intent of transferring the responsibility for this measurement beyond OSTM to the operational community.

OCEAN SURFACE TOPOGRAPHY ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	OCEAN SURFACE TOPOGRAPHY APPROACH
How is the global ocean circulation varying on interannual, decadal, and longer time scales?	OSTM is an oceanography mission to monitor global ocean circulation. It will also study the ties between the oceans and atmosphere, improve global climate forecasts and predictions, as well as monitor events such as El Niño conditions and ocean eddies. The potential instruments to be carried on the spacecraft include: 1. Nadir Altimeter to measure ocean topography – provided by CNES 2. Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) for precision orbit determination – provided by CNES 3. Microwave Radiometer for path delay correction 4. Wide Swath Altimeter for enhanced science measurements (optional) 5. Global Positioning System (GPS) receiver for precision orbit determination 6. Laser Retroreflector Array for precision orbit determination

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing.

Performance Plan Metrics Supported: See Annual Performance Goals 1A2 as described in scientific question section above.

Key Formulation Milestones:	FY 2003 BUDGET DATE	FY 2002 BUDGET DATE	BASELINE DATE	CHANGE	COMMENT
Systems Requirements Review	February 2002		February 2002		
Preliminary Design Review	April 2002		April 2002		
Mission Confirmation Readiness Review	July 2002		July 2002		
Planned launch readiness	2006		2006		

ROJECT STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

Formulation started in FY 2001 and start PDR in 2002.

PROJECT PLAN FOR FY 2003

Start implementation phase and Preliminary and Detailed Design Reviews.

PROJECT DATA- LANDSAT DATA CONTINUITY MISSION (LDCM)

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
LDCM Development	**1.5**	**12.0**	**45.0**

DESCRIPTION/JUSTIFICATION

LDCM continues the basic global land cover change data set. NASA is hopeful this can be accomplished with a commercial data purchase. NASA has released a Request for Proposal for the formulation phase as the next step in exploring this avenue. Contract awards are anticipated no later than CY 2002. This mission is currently in formulation and is being supported by GSFC and SSC.

The Landsat program has been continually acquiring imagery of the Earth's land surfaces since the launch of Landsat 1 in 1972. Landsat data are used for scientific research as well as a variety of applications including education, land management, and commercial endeavors. The Land Remote Sensing Policy Act of 1992 (P.L. 102-555) addressed maintaining the continuity of Landsat-type data beyond Landsat-7 into the next millennium. P.L. 102-555 also required Landsat Program Management (NASA and the United States Geological Survey (USGS)) to consider various management alternatives, with preference given to commercial involvement.

The LDCM Project will field a data specification-based procurement which leaves the means of providing and delivering those data up to the data vendor. Such a data specification has been written and subjected to public review by both user and vendor communities. The final contract will be for the delivery of these data and not the system that produces it. Technical performance must be demonstrated by the vendor to the Government.

The Government will retain an intimate role in the calibration, validation, and verification of the data itself. In addition, the Government will have complete insight into the concept, design, implementation of the design, and operation of the system producing these data.

LDCM ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	LDCM APPROACH
What changes are occurring in global land cover and land use, and what are their causes? What are the consequences of land cover and land use change for the sustainability of ecosystems and economic productivity? What are the consequences of climate and sea level changes and increased human activity on coastal regions?	Aside from the legal mandate, the objective of the LDCM is to provide synoptic, repetitive, multispectral, high-resolution, digital imagery of the Earth's land surfaces which periodically refreshes a global archive with substantially cloud-free, sunlit data; characterize and monitor change in land-cover and land-surface processes; improve the assessment of both the rates of land-cover change and the local processes responsible for those changes; observe deforestation, ecosystem fragmentation, agricultural productivity, glacier dynamics, and coastal hazards; and monitor volcanoes.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Identify and measure primary causes of change in the Earth system; Identify the consequences of changes in the Earth system for human civilization.

Performance Plan Metrics Supported: See Annual Performance Goals 1B2, 1D2, 1D3 as described in scientific question section above.

Key Formulation Milestones:	FY 2003 BUDGET DATE	FY 2002 BUDGET DATE	BASELINE DATE	CHANGE	COMMENT
Release Request for Information	July 9, 1999		July 9, 1999		
Release Draft Data Specification	November 6, 2000		November 6, 2000		
Release Formulation Phase RFP	November 1, 2001		November 1, 2001		
Award Formulation Phase Contracts	April, 2002		April, 2002		
Release Implementation Phase RFP	December, 2002		December, 2002		
Award Implementation Phase Contract	May, 2003		May, 2003		
Mission Design Review/Delta PDR	June 2003		June 2003		
Initial Receipt of Operational data	March 2006		March 2006		

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

A Request for Proposal for formulation study contracts was released and proposals were received in December 2001. In addition, workshops have been held with potential industry, government and commercial partners as part of the formulation Request for Proposal (RFP) development. During formulation we will be working with the formulation contractors to further define the process to enable a commercial data policy.

PROJECT PLAN FOR FY 2003

Start implementation phase and detailed Design Reviews.

PROJECT DATA- NPOESS PREPARATORY PROJECT (NPP)

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
NPP Development	**45.5**	**67.2**	**153.1**

DESCRIPTION/JUSTIFICATION

NPP continues fulfilling our national commitment to obtain and make available a 15-year data record for fundamental global climate change observations started by MODIS, AIRS, and the combination of AMSU/HSB, which are the primary instruments on the EOS Terra and Aqua satellites. This is also a shared cost precursor mission to the next generation of operational polar weather satellites being developed by the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Integrated Program Office (IPO), a joint NASA, NOAA, DoD effort. This arrangement assures NASA's long-term science observational needs are met by the operational system, and assures transfer of key technologies NASA developed as part of the EOS program into the next generation of operational satellites.

NPP ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION (Annual Performance Goal):	NPP APPROACH
How are global precipitation, evaporation, and the cycling of water changing? How is the global ocean circulation varying on interannual, decadal, and longer time scales? How are global ecosystems changing? What trends in atmospheric constituents and solar radiation are driving global climate? What changes are occurring in global	The instruments carried on the NPP spacecraft have the following technical characteristics: • Advanced Technology Microwave Sounder (ATMS) developed and provided by NASA – In conjunction with CrIS, provide daily global observation of atmospheric temperature and humidity profiles – similar to the AMSU/HSB instrument combinations; • Visible Infrared Imaging Radiometer Suite (VIIRS) developed and provided by NPOESS IPO – obtains global observation of land, oceans, and atmosphere for climate research and weather forecasting – similar to the MODIS instrument; • Cross-Track Infrared Sounder (CrIS) developed and provided by NPOES IPO – In conjunction with ATMS, provide daily global observation of atmospheric temperature and humidity profiles – similar to the AIRS, AMSU/HSB instrument combinations.

land cover and land use, and what are their causes? What are the effects of clouds and surface hydrologic processes on earth's climate? How do ecosystems respond to and affect global environmental change and the carbon cycle? What are the consequences of land cover and land use change for the sustainability of ecosystems and economic productivity?	

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Identify and measure the primary causes of change in the Earth system; Determine how the Earth system responds to natural and human-induced changes; Identify the consequences of changes in the Earth system for human civilization.

Performance Plan Metrics Supported: See Annual Performance Goals 1A1, 1A2, 1A3, 1B1, 1B2, 1C1, 1C2, 1D2 as described in scientific question section above.

Key Milestones:	FY 2003 DATE	FY 2002 DATE	BASELINE DATE	CHANGE (FY02-FY03)	COMMENT
Preliminary Design Review	4th Qtr 2002	December 2002	December 2002	+ 2 QTRS	Project in formulation. Revised due to schedule maturity
Critical Design Review	2nd Qtr 2003	January 2003	December 2003	+ 1 QTR	Project in formulation. Revised due to schedule maturity
Instrument Delivery to Integration &Test	November 2004	October 2004	October 2004	+ 1 month	
Spacecraft Integration	November 2004	November 2004	November 2004		

&Test			
Launch	NET December 2005	December 2005	December 2005

Lead Center: GSFC	**Other Centers:**	**Interdependencies:** NPOESS – Integrated Program Office (IPO)
Instruments	**Builder**	
Advanced Technology Microwave Sounder (ATMS)	Aerojet	
Spacecraft	TBD	
Ground System	TBD	
Data Processing Center	TBD	
Launch Vehicle: Delta II		

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

The NPP awarded the second phase of spacecraft study contracts in FY 2001, which will culminate in a Preliminary Design Review in FY 2002. Subsequent to these reviews, the NPP spacecraft provider will be selected in FY 2002. The Advanced Technology Microwave Sounder (ATMS) instrument implementation contract was awarded in FY 2001 and is proceeding toward a Critical Design Review in FY 2002

PROJECT PLANS FOR FY 2003

A joint NASA/IPO NPP Mission Preliminary and Critical design review will be conducted in FY 2003. The tentative launch readiness date is late 2005, which will be finalized as part of formulation process.

OTHER PRE FORMULATION STUDIES

PROJECT DATA- GLOBAL PRECIPITATION MISSION (GPM)

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
GPM Formulation	**2.0**	**11.3**	**8.0**

DESCRIPTION/JUSTIFICATION

Observations from the Tropical Rainfall Measurement Mission (TRMM) have demonstrated the value of these data in modeling the global water and energy cycle, which is an emerging science theme for both the ESE and the USGCRP. We are currently examining options for this mission.

GPM ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION (Annual performance Goal):	GPM APPROACH
How are global precipitation, evaporation, and the cycling of water changing? How are variations in local weather, precipitation, and water resources related to global climate variation?	Mission under study.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; identify the consequences of changes in the Earth system for human civilization

Performance Plan Metrics Supported: See Annual Performance Goals 1A1, 1D1 as described in scientific question section above.

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

Work toward completion of the final Advanced Study Review and draft Letter of Agreement with NASDA in FY 2002. Continue preliminary mission design reviews.

PROJECT PLAN FOR FY 2003

There is no commitment to this mission until the review of the USGCRP is complete.

OTHER PRE-FORMULATION STUDIES

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
OTHER PRE-FORMULATION STUDIES	**5.7**	**10.0**	**--**

SOLAR IRRADIANCE STUDY

This data provides the means to distinguish the external (solar) from internal sources of change in the Earth system. A follow-on mission is required to bridge the gap between the SORCE mission (2002) and NPOESS (2010). We are currently studying various options for technical and programmatic feasibility.

TOTAL COLUMN OZONE STUDY

Total ozone measurements are required to assess the anticipated recovery of the ozone layer as a result of the Montreal Protocol. Aerosols are the largest source of uncertainty in efforts to quantify the forces acting on climate. TOMS currently provides the former (with Aura picking it up in 2004), and SAGE the latter. This combined mission is required to fill the gap between Aura & SAGE, and NPOESS.

OCEAN VECTOR WINDS STUDY

The Ocean Vector Winds Mission (OVWM) will provide continuity of a high-quality, multi-decadal data set of ocean vector winds and wind-driven ocean circulation beyond NSCAT, QuikSCAT and SeaWinds, without any gaps, for climate studies, air/sea interaction studies, and meteorological forecasting. The OVWM scatterometer will use the same measurement approach used by the SeaWinds scatterometer. In preparation for the transition of the measurement to the operational platforms, steps will be taken to reduce the cost of producing the instrument, mass, power, volume, and potentially field of view. Formulation activities for this mission concept will include exploration of several mission implementation options that include collaborations with NASDA and NOAA to reduce the mission cost.

OTHER & FUTURE EOS FOLLOW-ON MISSIONS

In FY 2001, new Follow On studies were initiated in the following areas: Global Winds; Global Earthquake; and New Data and Information Systems and Services (New DISS). In FY 2002 some additional studies will be conducted relating to these and other possible future missions, but none will be initiated pending review of the USGCRP.

BASIS OF FY 2003 FUNDING REQUIREMENT

ALGORITHM DEVELOPMENT

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
Algorithm Development	**89.3**	**83.4**	**59.7**

DESCRIPTION/JUSTIFICATION

The EOS Algorithm activities consist of the development, maintenance, and operation of the algorithms that produce the EOS standard data products, including routine intellectual quality control of these products. As such, these activities serve to unite the flight instruments, science, and the information system. These activities ensure, in the form of the products produced, that the integrity, quality, and rigor of the total process extending from instrument and spacecraft operation to the actual archiving and distribution of the data and information products used by the broad earth science and applications communities are maintained.

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Continue to develop and complete/deliver algorithms for Aqua, ICESat, and SORCE. Continue development of Aura algorithms and algorithm maintenance for Terra and ACRIM. With the launch of the Aqua mission, the algorithm developers will begin to receive data in late FY 2002 and they will begin the process of assessing the health and status of the instruments and ancillary data from the spacecraft, and the sensors and, subsequently, checking pre-launch algorithms to assess their effectiveness on-orbit. "First-look" data products will need to be produced to demonstrate the operational readiness of the sensors for science and applications and then steps taken to fine-tune the algorithms and attendant code for production of data products.

PROGRAM PLANS FOR FY 2003

Continue Aura algorithm development and algorithm maintenance for Terra, Aqua, and ACRIM. With the launch of ICESat and SORCE, the algorithm developers will begin to receive data and they will begin the process of assessing the health and status of the instruments and ancillary data from the spacecraft and the sensors and, subsequently, checking pre-launch algorithms to assess their effectiveness on-orbit. "First-look" data products will need to be produced to demonstrate the operational readiness of the sensors for science and applications and then steps taken to fine-tune the algorithms and attendant code for production of data and information products.

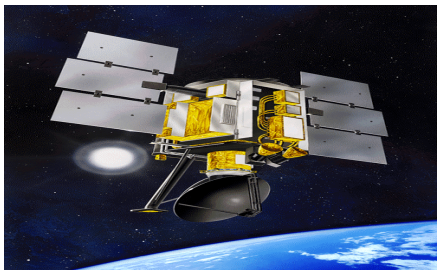
BASIS OF FY 2003 FUNDING REQUIREMENT

QUIKSCAT

Web Address: http://winds.jpl.nasa.gov/missions/quikscat/quikindex.html

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
QUIKSCAT Development *	**1.1**	**1.8**	**--**

* QUIKSCAT Total life cycle cost data is provided at the end of this section.



DESCRIPTION/JUSTIFICATION

The QuikSCAT mission, which is filling the ocean vector wind data gap created by the loss of the NASA Scatterometer (NSCAT) on the Japanese ADEOS I spacecraft, was launched from Vandenberg Air Force Base June 19, 1999. The Scatterometer data was released to the general science community on January 31, 2000. The reprocessing of all the data from the beginning of the mission, with improved rain flag and model function, was completed in July 2000. The Scatterometer has been operating for 29 months (as of November 2001), which is longer than any previous scatterometer. The prime mission ended on June 19, 2001, however, extended operations have been approved until September 30, 2002. The intent is to provide a six-month overlap between QuikSCAT and SeaWinds on ADEOS II to assure cross-calibration prior to phasing out QuikSCAT operations.

QUIKSCAT ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	QUIKSCAT APPROACH
How is the global ocean circulation varying on interannual, decadal, and longer time scales? What changes are occurring in the mass of the Earth's ice cover?	The SeaWinds instrument on the QuikSCAT satellite is a specialized microwave radar that measures near-surface wind speed and direction under all weather and cloud conditions over Earth's oceans. QuikScat is acquiring all-weather, high-resolution measurements of near-surface winds over global oceans. It is helping to determine atmospheric forcing, ocean response, and

What are the effects of clouds and surface hydrologic processes on Earth's climate? How are variations in local weather, precipitation, and water resources related to global climate variation? How can weather forecast duration and reliability be improved by new space-based observations, data assimilation, and modeling? How well can transient climate variations be understood and predicted?	air-sea interaction mechanisms on various spatial and temporal scales. It combines wind data with measurements from scientific instruments in other disciplines to help us better understand the mechanisms of global climate change and weather patterns. QuikScat measurements also enable study of the daily/seasonal sea ice edge movement and Arctic/Antarctic ice pack changes.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Determine how the Earth system responds to natural and human-induced changes; Identify the consequences of changes in the Earth system for human civilization; Enable the prediction of Earth system changes that will take place in the future.

Performance Plan Metrics Supported: See Annual Performance Goals 1A2, 1A5, 1C1, 1D1, 1E1 as described in scientific question section above.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-FY03 Change	Comment
Launch	June 1999	June 1999	April 1999		Successfully launched June 19, 1999

Lead Center: JPL

Other Centers: GSFC Rapid Spacecraft Development Office (RSDO)

Subsystem	Builder
Spacecraft	Ball – Contract managed by GSFC

Instruments	Builder
Scatterometer	JPL – In-house

Launch Vehicle: Titan II

Tracking/Communications: Ground Network

Data Handling: EOSDIS

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Spacecraft operations are nominal.

PROGRAM PLANS FOR FY 2003

Continuation of operations beyond FY 2002 is being assessed.

Space Infrared Telescope Facility (SIRTF)

QUIKSCAT LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	**84.8**									**84.8**
FY03 President's Budget	**84.4**	**1.1**	**1.8**							**87.3**
Development	**58.8**	**1.1**	**1.8**							61.7
Launch Vehicle	**25.6**									25.6
FTEs (number)									SAT 3-63	

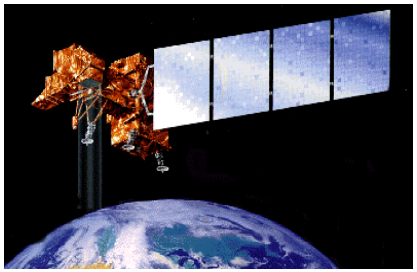
BASIS OF FY 2003 FUNDING REQUIREMENT

LANDSAT 7

Web Address: http://landsat.gsfc.nasa.gov/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
LANDSAT 7 Development *	**1.4**	**1.7**	**1.7**

* LANDSAT 7 Total life cycle cost data is provided at the end of this section.



DESCRIPTION/JUSTIFICATION

The Landsat-7 satellite was launched on April 15, 1999, and declared operational in July 1999. The satellite continues to return excellent images, which meet or exceed expectations. First data was available to the public mid-August 1999. By agreement with the USGS, NASA operated and funded operations through FY 2000. Landsat-7 is producing 150 Terabytes of data per day. Beginning in FY 2001 and beyond, the USGS is operating and funding the Landsat-7 system. NASA is providing technical and scientific anomaly support as needed

LANDSAT 7 ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	LANDSAT-7 APPROACH
What are the changes in global land cover and land use, and what are their causes? What are the consequences of land cover and land use change for the sustainability of ecosystems and economic productivity?	Landsat-7 systematically provides well-calibrated, multispectral, moderate resolution, substantially cloud-free, sun-lit digital images of the Earth's continental and coastal areas with global coverage on a seasonal basis using the Enhanced Thematic Mapper Plus Instrument.

What are the consequences of climate and sea level changes and increased human activities on coastal regions?	

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Identify and measure primary causes of change in the Earth system; Identify the consequences of changes in the Earth system for human civilization.

Performance Plan Metrics Supported: See Annual Performance Goals 1B2, 1D2, 1D3 as described in scientific question section above.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-FY03 Change	Comment
Launch	April 1999	April 1999	December 1998		Successfully launched April 15, 1999

Lead Center: GSFC	**Other Centers:**	
Subsystem Spacecraft	**Builder** Lockheed–Martin, Valley Forge, PA	
Instruments Enhanced Thematic Mapper Plus	**Builder** Ratheon SBRS	
Launch Vehicle: Delta II	Tracking/Communications: U.S. Geological Survey (USGS)	**Data Handling:** USGS Earth Resource Observation System (EROS)

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Spacecraft operating nominally.

PROGRAM PLANS FOR FY 2003

Continue operations through USGS.

LANDSAT 7 LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Total
Initial Baseline (lifecycle)	**391.3**								**391.3**
FY03 President's Budget	**502.1**	**1.4**	**1.7**	**1.7**	**1.9**				**508.8**
Development	**449.1**	**1.4**	**1.7**	**1.7**	**1.9**				455.8
Launch Services	**53.0**								53.0
FTEs (number)		(1)	(1)	(1)	(1)				

Outyear costs are for on-orbit incentive fees.

BASIS OF FY 2003 FUNDING REQUIREMENT

EOSDIS

Web Address: http://eos.gsfc.nasa.gov/proj-esdis.html

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
EOS Data and Information System *	**279.1**	**293.0**	**74.3**
Total.....	**279.1**	**293.0**	**74.3**

* EOSDIS Total life cycle cost data is provided at the end of this section.

DESCRIPTION/JUSTIFICATION

The EOSDIS facilitates the goals of Earth science by enabling the public to benefit fully from increased understanding and observations of the environment. The EOSDIS is operating the EOS satellites now in orbit, and retrieving flight data and converting it into useful scientific information. Development of EOSDIS is nearly complete; remaining activities are timed to provide releases to support the upcoming launches of EOS missions through Aura in 2004. The EOSDIS is providing the overall Program data system for EOS missions. NASA has developed and is operating EOSDIS as a distributed interoperable system which can: (1) operate the EOS satellites; (2) acquire instrument (science) data; (3) produce data and information products from the EOS spacecraft; (4) archive all these and other Earth science environmental observation data for continuing use; and (5) make all these data and information easily available for use by the research and education communities, government agencies and all those who can benefit from the data in making economic and policy decisions.

The EOSDIS is based on an evolutionary design to develop capabilities with the phased deployment of the EOS satellites and to enable adaptation to changes in user needs and in technology. The design is modular, allowing for the replacement of individual components without costly overall system changes or disruptions in service.

EOSDIS relies also on other agencies (such as USGS which manages the Landsat Data Processing system) and other countries (such as Japan for the ASTER science data production). EOSDIS allows direct access to data acquired from EOS satellites, selected pathfinder data holdings from the USGS and NOAA, and other heritage and ancillary data. Relationships with Canada, Japan, Russia, Israel, Australia and several European countries have been established for the exchange of data with EOSDIS. Many multi-agency efforts, in addition to the NASA EOSDIS, are working to improve data availability to the public, especially the Interagency USGCRP Data and Information Working Group and the Federal Geographic Data Committee.

The EOSDIS is currently supporting an array of satellites by providing mission operations, data capture, data production, data archive, data distribution, and user support. This system is designed to evolve over time as the data sources, missions, technologies, and user needs change. This has been affected, through the use of a combination of specialized core systems, user specific systems for instruments or scientific disciplines, commercial off-the-shelf items, and cooperative activities with heritage data centers to ensure continued support to established user communities. In addition, the expansion of data services is encouraged through cooperation with the Distributed Active Archive Centers (DAACS) Earth Science Information Partners (ESIPs), Regional Science Applications Centers (RESACs), and the Synergy task. The EOSDIS sustains a partnership with NOAA, USGS, and international partner space agencies.

The EOSDIS development has been divided into six major components:

1. The Polar Ground Stations (PGS) provide command uplink and telemetry downlink. The PGS are now part of the Ground Network (GN).
2. The EOS Data and Operations System (EDOS) which receives the raw data stream from the satellites, separates the data by instrument, and performs the initial processing (packet restoration and temporal ordering) and back-up archiving. EDOS interfaces to the TDRSS ground terminal at the White Sands Complex for Terra data, and will interface to the PGS in Alaska and Norway for data from the Terra, Aqua, ICESat, and Aura missions. The raw data collected from the satellites are sent to the EDOS Level-0 processing center at GSFC, which processes the data and sends them via EBNet to the DAACs and the Science Investigator-led Processing Systems (SIPS);
3. The EOS Mission Support Network (EMSN) delivers the real-time data to and from the mission operations control centers and the science data to the DAACs and SIPS. EMSN was originally developed by GSFC, but is now managed as part of SOMO/NISN;
4. The EOSDIS Core System (ECS) includes the Flight Operations Segment (FOS), which provides command and control capabilities to operate the EOS spacecraft (the present implementation of FOS is called the EOS Mission Operations System (EMOS)), and the Science Data Processing Segment (SDPS) which provides data product generation using science software provided by the Principal Investigators (PIs), data archiving, and distribution. The SDPS is operated at the DAACs;
5. The DAACs produce EOS standard data products using algorithm software provided by the PIs, archive data, and distribute these data to end users. Each DAAC focuses on the data needs of a specific segment of the user community, with User Working Groups advising individual DAACs. The eight DAACs are:
   - Alaska Synthetic Aperture RADAR (SAR) Facility, Geophysical Institute, University of Alaska, Fairbanks, Alaska
   - Earth Resources Observation System (EROS) Data Center (EDC), U.S. Geological Survey, Sioux Falls, South Dakota
   - Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California
   - Langley Research Center (LaRC), Hampton, Virginia
   - National Snow and Ice Data Center (NSIDC), University of Colorado, Boulder, Colorado
   - Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee
   - Socio-Economic Data and Applications Center (SEDAC), Lamont-Dougherty Earth Observatory, Columbia University, Palisades, New York
   - Goddard Space Flight Center, Greenbelt, Maryland

6. The SIPS provide data product generation at Instrument Team sites, and send the data via EMSN to the appropriate DAAC for archiving and general distribution. The SIPS produce data products in a way that takes advantage of the latest technologies and the instrument teams' expertise.

In FY 2003, the operations of EOSDIS will continue, the ECS contract for systems development will end, but a new system Maintenance contract will be established. Starting in FY 2003 the EOSDIS budget is separated into two parts (Development and Operations), to reflect the transition from development into an operational phase.

New Data Information Systems and Services (NewDISS)

NASA is looking to future data system needs and designs in several ways. The EOSDIS Working Prototype Federation experiment, initiated in 1998, is continuing to develop methodologies for decision making and interoperability in a collaborative, yet competitive, distributed data system topology. Members of the Federation represent the broad scientific and applications community and include representatives from educational institutions, industry, regional governments and consortia, and NASA data centers. NASA is also engaged in long-term planning for the evolution of the current Earth science data system. NewDISS is being formulated as a plan to evolve the current ESE data and information systems, infusing Lessons Learned from the NRC-recommended Federation prototype, over the next 6 to 10 years. This evolution will enable NASA to integrate data elements from the new missions now under formulation. The NewDISS concept allows for a heterogeneous mix of interdependent components of numerous individuals and institutions. Because the ESE already has made a considerable investment in existing data system components (e.g., DAACs, ECS, SIPS, and ESIPs), as well as product generation, the near-term NewDISS will necessarily evolve from these existing activities. In the long term NewDISS structure could be quite different from the current, as data systems and services evolve to meet science-driven demands and to take advantage of technological innovation.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: EOSDIS is an activity that enables achievement of all three Earth Science strategic goals.

Strategic Plan Objectives Supported: EOSDIS is an activity that enables achievement of all three Earth Science strategic goals and objectives.

Performance Plan Metrics Supported: Successfully disseminate Earth Science data to enable our science research and applications goals and objectives.

PROJECT SCHEDULE WITH CRITICAL MILESTONES

Version 1 Plan: January 1997 Revised: Replaced	Provide support for science data processing, archival, and management of the data from the two EOS instruments operating on the TRMM spacecraft. The ECS contractor failed initial test readiness for EOSDIS Version 1 and NASA issued a Stop Work Order. Replacement systems were developed by EOSDIS at GSFC and LaRC, (extended "Version 0" in-house system), and the systems are performing successfully.
Version 2 Plan and actual: January 1999 through December 1999	Mission Operations, processing, archiving and distribution for Terra; Processing, archiving and distribution for LANDSAT-7, Archive & distribution for: ACRIMSAT, JASON-1, QuikSCAT, SeaWinds, SAGE III.
Version 3 Plan: December 2000 Revised: July 2001	Provide science processing and flight operations support for Aqua and ICESat. EOSDIS components needed to meet the objectives of Version 3 are ready; integration and end-to-end testing are being carried out to match Aqua and ICESat launch schedules.
Version 4 Plan: September 2002	Provide science processing and flight operations support for Aura. Provide final incremental implementation of ECS A+ requirements. Schedule adjusted commensurate with Aura launch schedule. It is expected that the capabilities needed for Aura will be available per this schedule. However, work on this version will continue to support integration and testing to support the Aura launch in January 2004.

Lead Center: GSFC	**Other Centers:** GSFC, MSFC, LaRC, ARC, JSC, & JPL
Major Subsystems:	**Builder:**
EOSDIS Core System (ECS)	Raytheon
EOS Data & Operations Systems (EDOS)	TRW
Distributed Active Archive Centers (DAACs)	Various
Networks (Communications Systems)	JSC & MSFC
EOSDIS Federation	Various

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Continued deliveries of the ECS software are planned in FY 2002 to support requirements for the Aura mission, and operations readiness testing will ensure that all systems are ready and able to support the Aqua and ICESat launches. Capabilities will continue to be developed for users to create their own clients for searching and ordering data. The EOSDIS will continue to work to meet its planned performance targets. Indicators of this activity will be to continue making data available to users within 5 days of request and improving on prior year targets for archive, distribution, and number of customers served.

The EOS instrument teams are producing standard products under the SIPS concept based on the working Agreements established between the ESDIS Project and the instrument teams. MODIS, CERES, and MOPITT teams have been processing Terra data into standard products. They will continue their operations during FY 2002 and 2003. MODIS, CERES, AIRS, and AMSR-E teams are preparing to process Aqua data at their SIPS. They have been participating in the end-to-end tests of science data flow and are expected to be ready for the Aqua launch in March 2002. The development of SIPS by the four Aura instrument teams (HIRDLS, MLS, OMI, and TES) is under way and they are expected to be in place or completed in FY03 and be ready for the Aura launch in January 2004.

The EOSDIS is continuing to support processing, archive and distribution of an unprecedented amount of data and information. As a comparison, the EOSDIS effectively handles in one day more Terra data than the Hubble Space Telescope handles in a year or than the Upper Atmosphere Research Satellite (UARS) handles in 1.5 years. Some key indicators of EOSDIS performance are the volume of data archived (over 1000Terabytes at the end of FY 2001, including heritage data), the number of users accessing the DAACs (just under 1.47 million distinct users in FY 2000), and the number of data products delivered in response to user requests (approximately 15 million data products delivered in FY 2001). In the 2 years since the launch of Terra and Landsat 7, the EOSDIS has more than quadrupled NASA's Earth Science data holdings.

EOSDIS has been routinely providing and will continue to provide Earth science data products to end-users within 5 days of receipt of request or following production of the requested data product. These products comprise data from currently operating space assets including interdisciplinary data products from the Terra mission, land cover information from the Landat-7 satellite, ocean wind measurement from the QuikSCAT mission, precipitation measurements and observations of tropical storms from the Tropical Rainfall Measurement Mission (TRMM), ocean productivity measurements from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS), detection of ocean surface height changes used to predict El Niño occurrence and strength from the Topex/Poseidon Mission, solar energy input to the Earth from ACRIMSat, and sea ice motion and Antarctic mapping from U.S./Canada's RADARSAT. Also provided are measurements on stratospheric dynamics and trace chemicals from the UARS, the Antarctic Ozone Hole from the Total Ozone Mapping System (TOMS), land use and land cover from the heritage Landsat missions, and measurements of Earth and solar radiation from the Earth Radiation Budget Experiment (ERBE).

The ECS FOS continued to support the Terra spacecraft and instrument operations through 2001. ECS FOS capabilities have been tested numerous times during FY 2001 as a part of interface tests with the Aqua spacecraft. The FOS Instrument Support Terminals (IST), which allow instrument operations teams to plan for the operation of their instruments and monitor instrument performance from their home institutions, are installed and continue to be operational at all operations sites for the Terra instrument teams. ISTs have been installed at the major U.S. operations facilities in support of the Aqua spacecraft and instruments.

Other elements of EOSDIS are continuing to support the Terra mission. The EDOS overcame early problems with processing and distributing Terra science data (not unusual for a new mission of this complexity) and is successfully managing the Terra science data. Upgrades of EDOS to support Aqua and ICESat were made operational at the end of FY 2001. The EMSN and Polar Ground Stations are continuing to support Terra operations (PGS is backup to TDRSS for Terra) will make the necessary upgrades and enhancements to support the Aqua mission.

Development of the ECS SDPS has progressed well, and the system continues to provide sustained support for Terra and Landsat 7 operations at the DAACs. The data are being processed at better than "keep-up" rates, data from the SIPS are being ingested, and all processed data are being archived and made available for distribution. The system capacities have been augmented according to plan to accommodate planned ramp-ups in processing and reprocessing requirements. System upgrades were also made to improve user interface services, to add capabilities required for support of Aqua instruments, increase system capability, and to update to newer versions of Commercial-Off-The-Shelf (COTS) products.

The EOSDIS Federation experiment continued in FY 2001. The ESIP Federation was recently incorporated as a non-profit foundation, with the intent to serve the national Earth science research priorities such as USGCRP and CCRI and broader needs of the emerging environmental information economy. Such a Federation entity was envisioned in the original National Academy recommendation. The Federation membership has grown from the original 24 ESIPs to 40 ESIPs, including NASA's eight DAACs and one EOS science computing facility (SCF) and NOAA's National Climate Data Center. These groups are developing scientific products, collaborating with one another, both as single entities and in "clusters", and have collectively implemented a simple means of data set interoperability. NASA plans to continue its science-based ESIP program through a competitive solicitation in FY 2002.

The ECS Science and Flight Operations Segments received authority to process in December 2000, in accordance with the NASA Policy and Guidance (NPG) 2810.1 that mandates Information Technology (IT) security requirements for NASA data and systems. During FY 2001, security plans and documentation were completed, additional procedures were established, and Security Firewalls, capable of handling EOS data rates, were selected and procured. The Firewalls will complete testing and be deployed in early CY 2002.

PROGRAM PLANS FOR FY 2003

In FY 2003, the operations of EOSDIS will continue, the ECS development contract will end and a new Maintenance contract will be competed in FY 2002. Starting in FY 2003 the EOSDIS budget has been separated into two parts: (1) Maintenance and Development and (2) Operation. This change was required in order to reflect the operational nature of most of EOSDIS. This realignment reflects the true nature of the operations type activity. We have therefore transferred the appropriate elements into Earth Science Operations to reflect the transition from development to operations starting in FY 2003. The Strategy for Evolution of Earth Science Enterprise Data Systems (SEEDS) formulation activity will continue during FY 2002 and part of FY 2003.

In addition, The EOSDIS will continue to meet its performance goals as described in the FY 2003 performance plan:

Make available ESE acquired data and information on Earth's atmosphere, land and/or oceans to users within 3-5 days of their request.

Increase by 20-30% the total volume of data acquired by and available from NASA for its research programs compared to FY 2002. (This equates to a maximum of 1170 terabytes)

Maintain satisfactory support for the number of distinct NASA ESE data and information center customers compared to FY02. (This equates to 2,019,600 users).

Increase scientific and applications data products delivered from the ESE data and information centers by 10% compared to FY 2002. (This equates to 11,712,800 data products)

User Satisfaction: Maintain or improve the overall level of ESE data center customer satisfaction as measured by User Working Group surveys.

EOSDIS LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	**2,049.3**	**283.3**								**2,332.6**
FY03 President's Budget	**1,885.7**	**279.1**	**293.0**	**79.5**	**76.0**	**69.3**	**71.3**	**66.6**		**2,820.5**
Development	**1,821.2**	**260.7**	**274.0**	**62.4**	**59.3**	**52.7**	**56.1**	**57.7**		2,644.1
Federation/External	**60.4**	**13.6**	**11.3**	**8.9**	**8.9**	**8.9**	**8.9**	**8.9**		129.8
Jason/Sage Mission Ops	**4.1**	**4.8**	**7.7**	**8.2**	**7.8**	**7.7**	**6.3**			46.6
FTEs (number)		(104)	(112)	(120)	(132)	(141)	(128)	(128)		
Note: EOSDIS Ops transferred to Mission Ops				[176.6]	[206.3]	[201.7]	[199.8]	[206.6]		

BASIS OF FY 2003 FUNDING REQUIREMENT

EARTH EXPLORERS

Web Address: http://gaia.hq.nasa.gov/ese_missions

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
Total Ozone Mapping Spectrometer	2.0	--	--
Earth System Science Pathfinders	109.7	70.9	70.8
VCL	*13.7*	--	--
GRACE	*10.6*	*6.4*	*2.1*
CALIPSO (formerly PICASSO-CENA)	*30.1*	*31.0*	*33.8*
CloudSat	*47.6*	*23.8*	*27.4*
Program Support/Future missions	*7.7*	*9.7*	*7.5*
Experiments of Opportunity	0.9	2.3	0.4
Triana	24.9	1.0	--
University Class Earth System Science	0.4	--	--
Shuttle Radar Topography Mission	3.7	--	--
Total	141.6	74.2	71.2

DESCRIPTION/JUSTIFICATION

The Earth Explorers Program is the component of ESE that investigates specific, highly focused areas of Earth science research. It is comprised of flight projects that provide pathfinder exploratory and process driven measurements, answering innovative and unique Earth science questions. The program has the flexibility to take advantage of international cooperative efforts. It provides the ability to investigate processes having unique measurement requirements and which call for quick turnaround and reaction. The Earth Explorers Program contains a series of focused, rapid development missions to study emerging science questions and processes utilizing innovative measurement techniques as a complement to the systematic measurements made through the EOS.

The Earth Science System Pathfinder (ESSP) is a science-driven program intended to identify and develop in a relatively short time, small satellite missions to accomplish scientific objectives in response to national and international research priorities not addressed by current projects. ESSP will provide periodic “windows of opportunity” to accommodate ESE scientific priorities. By

launching ESSP missions on a regular basis, NASA will provide a mechanism by which pressing questions in Earth System Science may be addressed in a timely fashion, permitting a continual improvement in our understanding of the Earth system and the processes that control it.

The improved understanding, combined with improvements in predictive Earth system models, will provide our nation with the scientific basis for formulating well founded environmental and resource management policies.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Identify and measure primary causes of change in the Earth system; Determine how the Earth system responds to natural and human-induced changes; Identify the consequences of changes in the Earth system for human civilization: Enable the prediction of Earth system changes that will take place in the future

Performance Plan Metrics Supported: Annual Performance Goals as shown in Annual Performance Plan:1A1-1A6, 1B1-1B2, 1C1-1C6, 1D1-1D3, 1E1-1E5.

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

GRACE is on track for a March 2002 launch. NASA is currently in the process of selecting the third set of ESSP missions via ESSP Announcement of Opportunity (AO) #3. Mission selections for the formulation phase are planned for June 2002.

PROGRAM PLANS FOR FY 2003

Continue Development activities associated with CloudSat and CALIPSO in preparation for their co-manifested April 2004 launch.

BASIS OF FY 2003 FUNDING REQUIREMENT

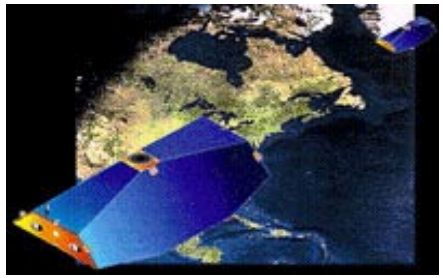
EARTH EXPLORERS PROGRAM - PROJECTS IN IMPLEMENTATION

GRAVITY RECOVERY AND CLIMATE EXPERIMENT (GRACE)

Web Address: http://www.csr.utexas.edu/grace/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
GRACE Development*	**10.6**	**6.4**	**2.1**

***** GRACE Total life cycle cost data is provided at the end of this section.



DESCRIPTION/ JUSTIFICATION

The GRACE mission (the 2nd ESSP mission) is led by a Principal Investigator from the University of Texas at Austin with significant participation by the German Aerospace Center (DLR). DLR is providing mission operations, launch services and science data analysis. GRACE will utilize an advanced microwave ranging system between two identical formation flying spacecraft to measure the Earth's gravitational field to an unprecedented accuracy by measuring the distance between the two satellites to within one micron. The planned launch date of GRACE on a contributed ROCKOT launch vehicle is March 2002.

The objective of the GRACE mission is to obtain accurate global and high-resolution models for both the static and the time variable components of the Earth's gravity field. The gravity field estimates obtained from data gathered by the GRACE Mission will provide, with unprecedented accuracy, integral constraints on the global mass distribution and its temporal variations. In the oceanographic community, the knowledge of the static geoid, in conjunction with satellite altimeter data, will allow significant advances in the studies of ocean heat flux, long term sea level change, upper oceanic heat content, and the absolute surface geostrophic ocean currents. Further, the estimates of time variations in the gravity field obtained from GRACE, in conjunction with

other in-situ data and geophysical models, will help the science community unravel complex processes in oceanography (e.g. deep ocean current change and sea level rise), hydrology (e.g. large scale evapo-transipiration and soil moisture changes), glaciology (e.g. polar and Greenland ice sheet changes), and the solid Earth sciences. Analysis of the data from GRACE will result in contributions to the understanding of variations in ocean bottom currents, ocean surface currents, ocean heat transport, polar ice and underground liquid reservoirs.

GRACE ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	GRACE APPROACH
How is the global ocean circulation varying on interannual, decadal, and longer time scales? What are the motions of the Earth and the Earth's interior, and what information can be inferred about Earth's internal processes?	GRACE will utilize an advanced microwave ranging system between two identical formation flying spacecraft to measure the Earth's gravitational field by measuring the variation in distance between the two satellites to unprecedented accuracy of one micron.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing

Performance Plan Metrics Supported: See Annual Performance Goals 1A2, 1A5 as described in scientific question section above.

Key Milestones:	FY 2003 DATE	FY 2002 DATE	BASELINE DATE	CHANGE (FY02-FY03)	COMMENT
Science Data Sys Complete	November 2001	November 2001	March 2000		
Instrument Sys Del	February 2001	September 2000	March 2000	+ 5 months	Late Delivery of Instrument Processing Unit
Precision Accelerometer Del	July 2000	July 2000	February 2000		
Satellite Delivery	March 2001	January 2001	March 2000	+ 2 months	Problems with on-board Data Handling Unit
Observatory & I&T Complete	August 2001	May 2001	March 2000	+ 3 months	Late Instrument Delivery
Ground Sys Dev Complete	October 2001	May 2001	November 1999	+ 5 months	Late documentation from Ground Station

Launch	March 2002	November 2001	June 2001	+ 4 months	Re-planned launch date reflects delays in flight instrument development and hardware anomalies that occurred during spacecraft environmental testing.

Lead Center: GSFC	**Other Centers: JPL, LaRC**	**Interdependencies:** Germany, France, Russia
Subsystem	**Builder**	**Pr. Investigator**
Spacecraft:	Astrium	Dr. Byron Tapley, University of Texas
Instruments	**Builder**	
Microwave Range Instrument	JPL/SS/Loral	
Precision Accelerometer	ONERA, France	
Science System	UT – CSR	
Launch Vehicle System	German Aerospace Center (DLR) Germany	
Ground System, Operations	DLR, German Space Ops Center (GSOC)	
Spacecraft Development & Integration	Astrium	
Launch Vehicle: German Rockot: Breeze KM upper stage, launched from Plesetsk Cosmodrome, Russia	**Tracking/Communications:** Polar Ground Network	**Data Handling:** University of Texas

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH 2002

The two GRACE spacecraft have completed environmental testing. The Operations Readiness Review was successfully conducted in November 2001 and the ground system is ready to support mission operations. The Pre-Ship Review occurred in December 2001. GRACE is scheduled to launch in March 2002.

PROJECT PLAN FOR FY 2003

Generation of data products will begin in late CY 2002 and continue for 5 years.

GRACE LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	**64.6**	**15.0**	**1.7**	**1.5**	**1.4**	**1.8**				**86.0**
FY03 President's Budget	**74.2**	**10.6**	**6.4**	**2.1**	**2.0**	**1.3**	**0.2**			**96.8**
Development	**74.2**	**10.6**	**3.6**							88.4
Mission Operations			**2.8**	**2.1**	**2.0**	**1.3**	**0.2**			8.4
FTEs (number)		(3)	(1)	(1)						

BASIS OF FY 2003 FUNDING REQUIREMENT

Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)

Web Address: http://www-calipso.larc.nasa.gov/picasso.html

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
CALIPSO Development *	**30.1**	**31.0**	**33.8**

* CALIPSO Total life cycle cost data is provided at the end of this section.

DESCRIPTION/JUSTIFICATION

The CALIPSO mission, (formerly PICASSO-CENA) was selected in December 1998. CALIPSO is designed to address the role of clouds and aerosols in the Earth's radiation budget. It will employ innovative Lidar instrumentation to measure the vertical distribution of clouds and aerosols in Earth's atmosphere. CALIPSO consists of a partnership between NASA and France's Centre Nationale D'Etudes Spatiale (CNES). CNES is providing a PROTEUS spacecraft, the imaging infrared radiometer (IIR), payload-to-spacecraft I&T, and spacecraft mission operations. CALIPSO will fly in formation with AQUA to provide a unique 3-year coincident global set of data on aerosol and cloud properties, radiative fluxes, and atmospheric state. This enables new observationally based assessments of the radiative effects of aerosol and clouds that will greatly improve our ability to predict the future state of Earth's climate. Together, CALIPSO and AQUA provide: (1) a global measurement suite from which the first observationally-based estimates of aerosol direct radiative forcing of climate can be made, (2) a dramatically improved empirical basis for assessing aerosol indirect radiative forcing of climate, (3) a factor of 2 improvement in the accuracy of satellite estimates of long wave radiative fluxes at the Earth's surface and in the atmosphere, and (4) a new ability to assess cloud-radiation feedback in the climate system. CALIPSO is co-manifested with Cloudsat and is scheduled to launch in April 2004.

CALIPSO ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	CALIPSO APPROACH
What trends in atmospheric constituents and solar radiation are driving global climate? What are the effects of clouds and surface hydrologic processes on earth's climate?	CALIPSO will provide key measurements of aerosol & cloud properties needed to improve climate predictions. CALIPSO will fly a 3-channel lidar and passive instruments in formation with Aqua and CloudSat to obtain coincident observations of radiative fluxes and atmospheric state. This comprehensive set of measurements is essential for accurate quantification of global aerosol and cloud radiative effects.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Identify and measure primary causes of change in the Earth system; Determine how the Earth system responds to natural and human-induced changes.

Performance Plan Metrics Supported: See Annual Performance Goals 1B1, 1C1 as described in scientific question section above.

Key Milestones:	FY 2003 BUDGETDA	FY 2002 BUDGET	BASELINE DATE	CHANGE (FY02-FY03)	COMMENT
Instrument Del to I&T	May 2003	March 2002	2001	+ 14 months	Mission Replan
S/C Bus Del to I&T	May 2003	March 2002	2001	+ 14 months	Mission Replan
Launch	April 2004	TBD	2003		Launch Slip from March 2003 to 4/04

Lead Center: GSFC	**Other Centers:** LaRC, KSC	**Interdependencies:** CNES (France)
Subsystem	**Builder**	
Spacecraft	CNES France	
Instruments	**Builder**	**Pr. Investigator**
Instrument Payload & Science Data Ground Sys (LIDAR, and Visible Wide-Field Camera)	Ball Aerospace	Dr. David Winker
Imaging Infrared Radiometer	CNES (France)	
Spacecraft	CNES (France)	
Launch Vehicle: Delta 7420 Co-manifested w/Cloudsat	**Tracking/Communications:** France Ground Station	**Data Handling:** France Ground Station and LARC

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH FY 2002

CALIPSO successfully completed the confirmation review process and proceeded into the implementation phase in April 2001. The payload CDR and Satellite Manufacturing Readiness Review were conducted in November 2001. Mission CDR is planned for February 2002.

The launch was moved from 2003 to April 2004 as a result of the Mission Confirmation Review finding that the planned mission was too aggressive to meet the earlier launch date given the risks associated with the laser development.

PROGRAM PLANS FOR FY 2003

Payload delivery is expected in Spring 2003.

CALIPSO LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	30.2	35.4	23.9	16.0	4.5	2.2				112.2
FY03 President's Budget	26.4	30.1	31.0	33.8	19.0	5.9	2.9	1.9		151.0
Development	26.4	17.9	31.0	22.3	11.9					109.5
Mission Operations					0.8	5.9	2.9	1.9		11.5
Launch Vehicle		12.2		11.5	6.3					30.0
FTEs (number)		(4)	(3)	(3)						

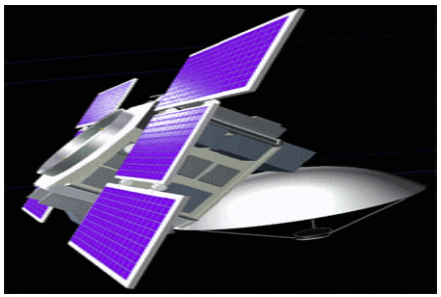
BASIS OF FY 2003 FUNDING REQUIREMENT

CLOUDSAT

Web Address: http://cloudsat.atmos.colostate.edu

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
CLOUDSAT Development*	**47.6**	**23.8**	**27.4**

* CLOUDSAT Total life cycle cost data is provided at the end of this section.



DESCRIPTION/JUSTIFICATION

CloudSat's primary objective is to furnish atmospheric observations needed to evaluate and improve the way clouds are parameterized in global models, thereby contributing to better predictions of clouds and their role in Earth's climate system. CloudSat will also fly for the first time in space a milli-meter wave radar that is capable of seeing practically all clouds and precipitation, from very thin cirrus clouds to thicker thunderstorms producing heavy precipitation. Cloudsat is co-manifested with CALIPSO and is expected to launch in April 2004. Cloudsat is a collaboration between NASA, the Canadian Space Agency (CSA), and the U.S. Air Force. CSA is contributing instrument components and the U.S. Air Force is contributing ground operations.

CLOUDSAT ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	CLOUDSAT APPROACH
What are the effects of clouds and surface hydrologic processes on earth's climate?	CloudSat is designed to measure the vertical structure of clouds from space. CloudSat will fly a millimeter-wave (94 GHz) radar that is capable of seeing a large fraction of clouds and precipitation from very thin cirrus clouds to thunderstorms producing heavy precipitation. CloudSat will furnish data needed to evaluate and improve the way clouds are represented in global models, thereby contributing to better predictions of clouds and a more complete knowledge of their role in climate change.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth.

Strategic Plan Objectives Supported: Determine how the Earth system responds to natural and human-induced changes.

Performance Plan Metrics Supported: See Annual Performance Goals 1C1 as described in scientific question section above.

Key Milestones:	FY 2003 BUDGET DATE	FY 2002 BUDGET DATE	BASELINE DATE	CHANGE (FY02-FY03)	COMMENT
Instrument Del to I&T	November 2003	2002	2002	+ 1 year	Delay due to CALIPSO replan
S/C Bus Del to I&T	November 2003	2002	2002	+ 1 year	Delay due to CALIPSO replan
Launch	April 2004	2003	2003	+ 1 year	Co-manifest w/CALIPSO

Lead Center: GSFC

Other Centers: JPL, KSC

Interdependencies: Canadian Space Agency (CSA)

Subsystem	Builder
Spacecraft	Ball Aerospace

Instruments	Builder	Pr. Investigator
Spacecraft Bus	Ball Aerospace	Dr. Graem Stephens, Colorado State
Adv Cloud-Profiling Radar	JPL	
Klystron for Radar	Canadian Space Agency (CSA)	
Electronics for Radar	Canadian Space Agency (CSA)	

Launch Vehicle: Delta 7420
Co-manifested w/CALIPSO Launch

Tracking/Communications: USAF Research Support Complex, NM

Data Handling: Colorado State

PROJECT STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Cloudsat successfully completed mission CDR in August 2001. In the 2nd quarter of 2002 The Cloud Profiling Radar Flight Model will be delivered and Spacecraft Bus I&T will start. Instrument I&T with the Spacecraft will begin 3rd quarter of 2002.

PROJECT PLAN FOR FY 2003

The Pre-Environmental Review is scheduled for 1st Qtr. 2003. System I &T will continue in 2003 along with continued Operations System Development. CloudSat will be put in storage awaiting co-manifested launch with CALIPSO in April 2004.

CLOUDSAT LIFE CYCLE COST DATA

$ in Millions	Prior	FY 2001	FY 2002	Y 2003	FY 2004	FY 2005	FY 2006	FY 2007	BTC	Total
Initial Baseline (lifecycle)	**21.3**	**49.8**	**29.8**	**10.3**	**3.1**	**1.5**				**115.8**
FY03 President's Budget	**20.7**	**47.6**	**23.8**	**27.4**	**16.5**	**2.6**	**1.6**			**140.2**
Development	**20.7**	**35.7**	**23.8**	**15.9**	**8.4**					104.5
MO					**1.8**	**2.6**	**1.6**			6.0
Launch Vehicle		**11.9**		**11.5**	**6.3**					29.7
FTEs (number)		(1)	(1)							

BASIS OF FY 2003 FUNDING REQUIREMENT

EARTH EXPLORERS PROGRAM – ESSP OTHER

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
Earth Explorers Program – ESSP Other	**21.4**	**9.7**	**7.5**

VEGETATION CANOPY LIDAR (VCL)

The principal goal of the VCL mission (selected under the first ESSP AO) is the characterization of the three-dimensional structure of the Earth's vegetation. The two main science objectives are land cover characterization for terrestrial ecosystem modeling, and generation of a global reference data set of topographic spot heights and transects. VCL contributes primarily to the Land Cover Change & Global Productivity theme in the Earth Science Enterprise Strategic Plan.

Delays in instrument development due to technical complications have led to a TBD launch date. After a program reassessment by NASA, VCL funding was suspended in FY 2001 until the laser technology issues can be overcome. The laser related activities are continuing as a technology effort in FY 2002

PROGRAM SUPPORT/FUTURE MISSIONS

Provides for the evaluation of the 3rd ESSP Announcement of Opportunity (AO) as well as administrative and program support activities.

BASIS OF FY 2003 FUNDING REQUIREMENT

EARTH EXPLORERS PROGRAM – OTHER

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
Total Ozone Mapping Spectrometer (QuikTOMS)	2.0	--	--
Experiments of Opportunity	0.9	2.3	0.4
Triana	24.9	1.0	--
University Class Earth System Science	0.4	--	--
Shuttle Radar Topography Mission (SRTM)	3.7	--	--

QuikTOMS

The scientific objectives of the TOMS project were to measure the long-term changes in total ozone and to verify the chemical models of the stratosphere used to predict future trends. The TOMS flights build on the experience that began in 1978 with the launch of a TOMS instrument (flight model 1) on Nimbus-7 and continued with the TOMS instrument (flight model 2) on a Russian Meteor-3, launched in 1991, a TOMS (flight model 3) launched on the Japanese ADEOS in 1996 and the Earth Probe spacecraft also launched in 1996. The development of a fifth TOMS instrument flight model 5 was launched on September 21, 2001 on QuikTOMS. The QuikTOMS spacecraft was procured through the Indefinite Delivery Indefinite Quantity (IDIQ) rapid delivery spacecraft contract. The QuikTOMS observatory was launched as a secondary payload with Orbview 4; unfortunately, the QuikTOMS mission was lost due to a Taurus launch vehicle failure.

Experiments Of Opportunity

This project offers a capability to undertake short duration flights of instruments on the Space Shuttle and other platforms. The ESE has used the capability of Shuttle/Spacelab development in the important areas of design, early test and checkout of remote sensing instruments for free flying missions, and short-term atmospheric and environmental data gathering for scientific analysis. Instrument development activities have supported a wide range of instrumentation, tailored for Space Shuttle and airborne missions. Current experiments include:

- SAC-C, a joint mission between NASA and the Argentine Space Agency (CONAE) was launched November 2000. SAC-C is currently operational and is providing science data.

- Infrared Spectral Imaging Radiometer (ISIR), the follow-on of the (ISIR), the COmpact Visible and Infrared Imaging Radiometer (COVIR) Instrument developed under the Instrument Incubator Program (IIP), completed full design as a shuttle

hitchhiker instrument. In FY 2002, a major issue is to manifest the COVIR hitchhiker experiment on a shuttle mission (dependent on developments in the shuttle program). If manifested, will complete the COVIR hitchhiker payload and complete a shuttle test flight with the Shuttle Laser Altimeter (SLA-03).

- (SLA-03), improved software for laser footprint geolocation and completed reprocessing of SLA-01 and SLA-02 data. Hardware design was reconfigured to incorporate new laser altimeter technologies developed in the IIP Micro altimeter experiment. Instrument redesign will be finalized by the end of December 2001. By December 2002, will complete integration and test of SLA-03 instrument, in preparation for delivery to the Shuttle Small Payload Hitchhiker Project (flight on STS mission is TBD, pending manifest).

- Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), is a joint U.S. and Taiwan project that will use the radio occultation/limb sounding technique to estimate important weather and climate parameters such as atmospheric temperature, moisture, and pressure. COSMIC will also measure electron density in the ionosphere. The source of the radio signals will be transmissions from the GPS satellites. COSMIC will consist of six low-Earth-orbit micro satellites, each equipped with GPS receivers designed by JPL. By providing more than 3,000 soundings per day, globally, and in all weather, the COSMIC constellation will significantly augment the current global observing systems and provide much-needed data for improved forecasting of terrestrial and space weather, ionospheric and climatic research, and monitoring of climate variability and change. COSMIC partners include the University Corporation for Atmospheric Research (UCAR), the National Science Foundation (NSF), Taiwan's National Space Council (NSC) and National Space Program Office (NPSO), NASA/JPL, the U.S. Naval Research Laboratory, the University of Arizona, Florida State University, the University of Texas, and the Orbital Sciences Corporation.

Triana

The Triana mission is an Earth observation spacecraft to be located at the Sun-Earth L1 point providing a near-term real time, continuous scientific observations of the full sun-lit disc of the Earth. During 1998 the mission was studied at GSFC and NASA Headquarters released an AO in July soliciting proposals for full Triana mission implementation. A selection was made in October 1998 for the Scripps Institution of Oceanography to build and conduct the Triana mission. Triana is designed to carry the Earth Polychromatic Imaging Camera built by Lockheed Martin Advanced Technology Company, a radiometer built by the National Institute of Standards and Technology, and a plasma magnetometer that measures solar wind built by GSFC and the Massachusetts Institute of Technology. In October 1999, the Triana mission suspended work per Congressional direction, while the National Academy of Science (NAS) conducted its review of the scientific merits of the mission. In April 2000, after a favorable finding, work was restarted. However, the stand down resulted in Triana being unable to support the previously assigned Shuttle Transportation System (STS) launch. The Triana instruments and spacecraft have completed environmental testing as an observatory and are currently in storage awaiting launch readiness call-up.

Shuttle Radar Topography Mission (SRTM)

The SRTM was flown on STS-99 in February 2000. SRTM was a joint NASA and National Imaging and Mapping Agency (NIMA) mission, which collected an unprecedented 8 Terabytes of interferometric Synthetic Aperture Radar (SAR) data (equivalent to about

12,300 CDs). This data will be processed to provide topographic data products over approximately 80% of the Earth's landmass (between 60° North and 56° South latitude).

BASIS OF FY 2003 FUNDING REQUIREMENT

RESEARCH and TECHNOLOGY

Web Address: http://earth.nasa.gov/

RESEARCH AND TECHNOLOGY

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
Earth Science Program Science	350.2	340.5	353.9
Applications, Commercialization and Education	114.1	--	--
Applications, Education, and Outreach (FY 2002 and out)	--	94.8	61.7
Technology	99.9	101.8	87.3
Construction of Facilities	--	--	3.4
Total	564.2	537.1	506.3

PROGRAM GOALS

The goal of Research and Technology is to advance our understanding of the Earth system with focus on earth's climate system and its variations due to natural forces and human activities, and the provision of numerical models and other tools necessary for assessing the future state of global climate and its variations.

DESCRIPTION/JUSTIFICATION

The Research and Technology program is divided into three components:

- Scientific investigations focused on applied and basic Earth science research, analysis, and data analysis of related EOS and other mission science data. Included is the Suborbital Science Program of crewed aircraft and uninhabited aircraft available to researchers and PIs. There is both disciplinary-oriented science that typically focuses on one component or process of the Earth system and interdisciplinary science that emphasizes the linkages between Earth system components. Also included is funding to support the provision of computing infrastructure. The Applications Program serves the Nation by demonstrating practical uses of NASA sponsored ***observations*** from remote sensing systems and ***predictions*** from scientific research. NASA implements projects through partnerships with public, private, and academic organizations. These partnerships focus on innovative approaches for using Earth science information to provide decision support that can be adapted in applications nationwide.

- The Applications Program transfers scientific knowledge, spatial information and data, and technical capabilities of Earth science between the research domain and the operational domain. The Applications, Education, and Outreach functions provide key linkages between NASA and its partners and constituencies in the public, private and academic sectors. Earth Science advanced technology focused on development of key technologies to enable our future science missions by reducing their development time and cost while reducing their development risks in support of ESE future missions.

- The Earth Science advanced technology program is focused on development of key technologies to enable our future science missions by reducing their development time and cost.

The major components of Research and Technology are focused on the ESE goals and objectives with specific major milestones, deliverables and measures of their performance.

BASIS OF FY 2003 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY

EARTH SCIENCE PROGRAM SCIENCE

Web Address: http://www.earth.nasa.gov/science/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		(Millions of Dollars)	
Research and Analysis – Science	169.8	156.1	162.2
EOS Science	48.4	49.2	53.6
Mission Science Teams - Research	96.2	94.6	102.6
Airborne Science and Applications	22.6	23.0	--
Sub Orbital Science	--	--	25.0
Uncrewed Aerial Vehicles (UAV)	3.5	4.0	--
Information Systems	9.7	13.6	10.5
Total	350.2	340.5	353.9

DESCRIPTION/JUSTIFICATION

Scientific investigations focused on applied and basic Earth science research, analysis, and data analysis of related EOS and other mission science data. Included is the Suborbital Science Program of crewed aircraft and uninhabited aircraft available to researchers and PIs. There is both disciplinary-oriented science that typically focuses on one component or process of the Earth system and interdisciplinary science that emphasizes the linkages between Earth system components. Also included is funding to support the provision of computing infrastructure.

PROGRAM GOALS

The goal of Earth Science Program Science research is to develop a scientific understanding of the Earth system and its response to natural or human-induced changes to enable improved prediction capability for climate, weather, and natural hazards. The Earth Science Program supports the research and analysis and integration of critical observations, with earth system models needed to characterize the variability in the earth system and the natural and human-induced forcing factors that affect it; to understand the process by which the Earth system responds to forcing; to assess the regional and global consequences of Earth system variability; and to develop the predictive capability for the Earth system.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth.

Strategic Plan Objectives Supported: Discern and describe how the global Earth system is changing; Identify and measure primary causes of change in the Earth system; Determine how the Earth system responds to natural and human-induced changes; What are the consequences of change in the Earth system for human civilization? Identify the consequences of changes in the Earth system for human civilization; How well can we predict future changes in the earth system?

Performance Plan Metrics Supported: Annual Performance Goals as shown in Annual Performance Plan:1A1-1A6, 1B1-1B2, 1C1-1C6, 1D1-1D3, 1E1-1E5.

CONTENT

Research and Analysis - The intellectual capital for both the planning and exploitation of Earth system observations is vested in a robust research and analysis program. Research and analysis constitute the conceptual source of Earth system science questions, and strategies to address them. The research program is at the origin of new scientific ideas and emerging research approaches. It supports the early development of innovative observing techniques (including both instruments and the linkage of instruments with platforms) and processing algorithms, organizes field tests, and generally charts the path of scientific and engineering developments that enable future advances. It assures the linkage between global satellite observations, ground-, aircraft- and balloon-based observation. In addition, it includes those used for studies of long-term Earth system evolution and shorter-term process-oriented studies. It also includes computational models used to provide both a framework for interpretation and assimilation of observations and a tool for prediction.

EOS Science - Consists of research aimed to assure that the EOS data can be accurately validated to ground, airborne and other space-based measurements, as well as interdisciplinary investigations. These interdisciplinary investigations are oriented towards improving understanding of how the Earth works as a system involving multiple interacting components. The former is needed to assure the quality of data produced by EOS instruments, many of which will be producing the first space-based data of their type. The latter are needed to assure creative use of multiple data types together with research models to address high priority ESE scientific questions associated with Earth system components and the linkage among them.

Mission Science Teams - Contribute to interpreting and exploiting scientific knowledge similar to Research and Analysis while focusing on optimum utilization of the on-orbit ESE instruments. Specific teams analyze data sets from operational spacecraft that support global climate change research focused on answering high priority ESE science questions in atmospheric ozone and trace chemical species, the Earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology.
Sub Orbital Science - Combines the Airborne Science and Uninhabited Ariel Vehicle UAV) programs into one program. The program enables the 1) Calibration/ Validation of space borne sensors, 2) Science Data Collection not available through space borne systems, and 3) Flight demonstration of future earth science sensors. By integrating UAV with Airborne Science under one program

ESE will be able to integrate all available observational capabilities in an end-to-end approach focused on answering its high priority science questions and be better able to manage the transition from the ESE current airborne assets to new platforms as technologies provide more capabilities or reduced operations costs. The ESE current operational platforms are two ER-2s, one DC-8 aircraft, and one P-3B. This includes operation and support of a core of remote sensing instruments and a facility for analyzing and calibrating data from those instruments. ESE also makes arrangements for use of other aircraft when they provide the most cost effective means of providing a platform for observations for specific studies.

Information Systems – Compliments the ESE modeling and data assimilation activities by providing a balanced system of high performance computers, software engineering tools, mass storage systems, workstations, and appropriate network connectivity between researchers and components of the system. A major portion of the project funding supports operation of a supercomputing center (the NASA Center for Computational Sciences) at GSFC and ARC. A full range of computational services is provided to a community of approximately 1,400 users representing all disciplines of Earth and space sciences. The project monitors and participates in advanced technology projects, such as the High Performance Computing Center (HPCC) program and National Science Foundation's gigabit test bed programs. The project is focused on providing early access to emerging technologies for the Earth and space science communities. The early access to new technology provides the project with the opportunity to influence vendors and system developers on issues unique to the Earth science researchers such as data intensive computation and algorithm development. Early access also prepares a subset of the research community to adopt and incorporate advanced software and hardware engineering computational methodology to exploit the new technologies and to champion them to their colleagues and peers.

SCHEDULE AND OUTPUTS

Research & Analysis	FY 2001 Estimate/Actual	FY 2002 Estimate	FY 2003 Estimate
Number of principal investigators	1,208/975	930	985
Number of research tasks under way	1,906/1,547	1,475	1,560
Average duration of research tasks	3 years	3 years	3 years
Number of science solicitations released	12/3	6	6
Number proposals received	1,125/539	1,125	1,300
Number of proposals rated very good to excellent	317		
Number of proposals selected	219		
Time to process proposal (selection through obligation)	45 days	45 days	45 days
Number of days until funding is released	Simultaneously with award	Same	Same
Percent of R & A funding obligated:			
Current Budget Authority:	95%/85%	95%	95%
Prior Budget Authority:	100%	100%	100%
Percent of program reviewed by science peers	90%	90%	90%

MAJOR RESEARCH & ANALYSIS RESULTS IN PAST YEAR

NASA's annual results in Earth Science are measured in terms of progress made toward answering the five research questions. In previous years, NASA developed a Performance Plan with specific research objectives which if met will constitute substantial progress in our understanding of the research questions. NASA ESE is currently developing roadmaps for each of its research objectives, which will be used to assess progress in future years. Outlined below are samples of ESE performance plan activities accomplished in FY 2001 that have advanced our understanding of Earth System Science.

- GSFC produced the first global record of the Earth's biosphere, showing the uptake and release of carbon by land and oceans continuously over three years. NASA-sponsored research showed that the growing season over parts of the Northern hemisphere has lengthened over the past two decades, with an accompanying increase in the lushness of vegetation.

- NASA and EarthSAT Corporation released the first consistent 30-m resolution land cover map for the U.S., and are nearing completion of the global map. These data are from 1990 and provide a basis for comparison of future change; plans are in work to repeat the process for 2000 and beyond.

- Results from a major NASA/NSF -led international research campaign indicate that aerosols from dust and pollution may be reducing evaporation and thus slowing the global water cycle.

- Results from comparing the 2000 and 1997 Antarctic Mapping Missions have led to new estimates of change in the Antarctic ice sheet; ice in the Lambert glacier flows from the interior to the "mouth" where it reaches a rate of 1 kilometer per year.

- In the Northern hemisphere, NASA researchers identified patterns of change in sea ice extent over a twenty-year period; overall, Arctic sea ice extent has decreased since 1978.

- Continued monitoring of global ocean topography showed that the Pacific Decadal Oscillation governs climate impacts of the Pacific in non- El Niño/La Nina years, and allowed the prediction of last winter's chill across the northern U.S. and relative warmth across the South.

- ESE also made major advances in computing for climate modeling, using a partnership among two NASA Centers and Silicon Graphics, Inc. to simulate 900 days of Earth's climate in one day, up from the prior capability of 70 days per day; performance on end-to-end climate simulation improved ten fold. This greatly enhances climate modelers' ability to perform the multiple runs of many years of climate simulations needed to generate useful projections of climate change.

- Tracked hazardous smoke and smog around the globe using the ESE Total Ozone Mapping Spectrometer Earth Probe (TOMS-EP) and international partnerships. Early warning of pollution events can help to mitigate their potentially hazardous affects on human health.

- Announced the beginning of summer with data collected from the EOS Terra spacecraft showing the Sun's affects on our planet. Based on Terra's ability to collect data twice per day over the entire planet, researchers were able to gauge the year's heat wave in California.

- Expanded knowledge of atmospheric chemistry by conducting a successful international field experiment, called the Transport and Chemical Evolution over the Pacific (TRACE-P) airborne campaign, in March/April 2001. The primary mission objectives were to understand the atmospheric plume flowing out of East Asia, the way in which it changes as it moves eastward over the Pacific Ocean, and its contribution to global atmospheric chemical composition. To conduct this research, ESE scientists combined data collected by two specially equipped NASA airplanes flying near Hong Kong and Japan with satellite and ground station measurements taken over the 45-day campaign. By studying the seasonal airflow from Asia across the Pacific, researchers gained insight into the way in which natural and human-induced changes affect our global climate.

- Discovered that during periods of increased solar activity the U.S. might become cloudier. Through a scientific paper published in the Geophysical Research Letters, NASA-funded researchers suggested that solar activity affects the jet stream over North America, possibly causing a change in cloud cover patterns.

- Discovered that hazardous bacteria and fungi might be crossing the Atlantic via dust plumes from Northern Africa and causing human health problems in the Virgin Islands and/or Miami. NASA and USGS researchers analyzed NASA Sea-viewing Wide Field-of-view Sensor data and field measurements to make this conclusion.

- Conducted the Fourth Convection and Moisture Experiment in August 2001. The field campaign was a complex space, air, and sea effort designed to study how hurricanes are born, how they choose the course they take, and how their tremendous power transports water and energy into the atmosphere. The mission combined the resources of five NASA centers, the NOAA, the Air Force and some 80-university researchers.

- Researched aerosols (small liquid droplets or particles in the air) and coastal ocean characteristics along the U.S. East Coast through the Chesapeake Lighthouse and Aircraft Measurements for Satellites campaign. The space, air, and water-based field campaign improved satellite-based estimates of aerosols and coastal ocean characteristics.

- Produced the first-ever global map of air pollution in partnership with the Canadian Space Agency. Used data from the EOS Terra satellite policymakers and scientists now have a way to identify the major sources of air pollution and can closely track movement of the pollution anywhere on the globe.

- Detailed the effect of the Hawaiian Islands on thousands of miles of ocean and winds. In a *Science Magazine* paper, scientists at the NASA JPL and their colleagues at the University of Hawaii discussed how the wake of the islands affects the local atmosphere and Pacific Ocean.

PROGRAM PLANS THROUGH FY 2003

The baseline ESE program is pursuing a targeted research program, focused on the science questions. ESE performance will be measured in terms of progress made toward answering these questions. Below is a sampling of planned activities.

How is the global Earth system changing? The Earth and Sun constitute a complex dynamic system that varies on all time-scales, from minutes to days in the case of severe weather disturbances, to many millions of years in the case of tectonic phenomena. The first challenge is to observe and understand this variability on all spatial and temporal scales.

- Implement passive and active rainfall retrievals from the TRMM to establish a benchmark for long-term global precipitation data records in support of the World Climate Research Program.

- Use calibrated data sets for determining long term trends in the total column and profile abundances of stratospheric ozone with sufficient precision to enable the later assessment of expected ozone recovery.

- Provide the first record of changes and variability in extent of Greenland ice sheet surface melt over the 21 years, 1979-1999, and produce the first high-resolution synthetic aperture radar "mini-mosaics" for key coastal regions in Antarctica to be used as a baseline for comparison to past and present high-resolution imagery. These products will provide information as to whether Polar Regions are in the process of losing mass and contributing to the current observed sea level rise.

- Use sub-monthly analysis from a data-assimilating global ocean model, using NASA and other agency satellite and in situ observations, to evaluate ocean circulation changes such as those associated with El Niño. This work is done in the context of the Global Ocean Data Assimilation Experiment. Establishing the basis for variations in the temperature and circulation of the upper ocean can be used to help assess any changes that may be affecting the Earth's weather and climate.

What are the primary forcings of the Earth system? Forces acting on the Earth system are both external and internal, and both natural and human-induced. The larger challenge is to quantify these forces accurately enough to detect trends and discern the patterns of change they bring about in climate and ecosystems.

- Use data assimilation techniques to combine Carbon Monoxide and Methane measurements from MOPITT with chemical transport models of the atmosphere to help characterize inter-annual differences in global emissions.

- Provide first comprehensive multi-instrument/multi-angle integrated data set for study of sources/sinks and distribution of tropospheric aerosols over land based on data from TOMS, MODIS, and MISR instruments.

- Reduce the uncertainty in the retrievals of upper troposphere/lower stratosphere water vapor (from microwave soundings) by 10 – 30% through improved laboratory spectroscopic measurements of the water vapor continuum, which will lead to

improved parameterization of water vapor distribution in the vicinity of the tropopause where it provides a major contribution to climate forcing.

- Characterize the role of land cover changes associated with natural fires in determining the carbon balance of ecosystems in at least two major regions of the boreal forests and quantify their impact on the global carbon budget, which will allow for improved knowledge of carbon sources and sinks that may be used in developing the models used to represent future evolution of atmospheric CO2 and CH4 amounts.

- Characterize the role of deforestation in the carbon balance of ecosystems of the Amazonian tropical forest, quantify the impact on the global carbon budget, which will provide policymakers with an understanding of the contribution to atmospheric carbon fluxes of land use within the world's largest tropical forest.

How does the Earth system respond to natural and human-induced changes? Earth's response to forces of change can turn into secondary causes of Earth system variability. The key to understanding this process is the development of models which couple the ocean, atmosphere, and land together in order to probe causes and affects which cross boundaries among Earth system components.

- Use results of the Cirrus Regional Study of Tropical Anvils and Layers – Florida Area Cirrus Experiment (CRYSTAL-FACE) field study to determine the upper tropospheric distribution of ice particles and water vapor and associated radiation fluxes on storms and cloud systems, and on cloud generation, regeneration and dissipation mechanisms and their representation in both regional-scale and global climate models, which will lead to improved estimates of climate forcing, the impact of these cloud systems on the hydrological cycle and weather system modeling.

- Demonstrate the feasibility of using remote sensing imagery to identify functional groups of phytopplankton in the ocean and develop a relationship between oceanic primary productivity and export of carbon to the deep-sea based on remote sensing observations and ocean biology models, which will provide an understanding of how fishery habitats and their distribution are affected by marine and coastal food sources.

- Evaluate measurement approaches for vegetation recovery and biomass change following forest clearing and impact of this secondary growth on removal of water from the atmosphere, which will allow for improved estimation of the effects of land cover change on regional ecology and hydrology and the resulting impacts on the carbon and water cycles.

- From TOPEX time series, in situ observations of the World Ocean Data Assimilation Experiment, and assimilation of these data into ocean models, ascertain whether detectable changes in the deep ocean have occurred over the last decade to provide improved knowledge of the way oceans may reflect the overall warming in the Earth system, which can then be used to improve climate models used for long-term assessment.

- Use twenty years of "Fram Strait" sea ice flux from RADARSAT and passive microwave ice motion to improve the accuracy of climate models used in assessments. Sea ice flux through the Fram Strait represents export of fresh water from the Arctic Ocean, which in turn influences deep ocean circulation and climate variations.

- Characterize the atmospheric plume from East Asia and assess its contribution to regional and global atmospheric chemical composition by completing the archival of the Transport of Chemical Evolution over the Pacific (TRACE-P) airborne mission and associated data sets, which will allow improved assessment of intercontinental transport of pollution.

What are the consequences of change in the Earth system for human civilization? Small changes in the global distribution of Earth system properties such as mean surface temperature or sea-level pressure, can entail changes of much greater significance in regional weather, productivity patterns, water resource availability, and other environmental attributes that directly impact human lives.

- Use the inter-annual variations of deep tropical convection utilizing existing and new satellite-based datasets to understand relations between large-scale surface and atmospheric forcing and tropical forcing and enable improved knowledge of how tropical phenomena affect weather and water availability globally.

- Demonstrate impact of assimilation of TRMM rainfall data on forecasting track and intensity of tropical storms by showing improvement in near real-time hurricane and typhoon forecasts in a variety of cases/conditions.

- Use models incorporating the biophysical, socio-economic, institutional, and demographic determinants of land use and land cover change in Amazonia that will enable more realistic representation of human-induced changes on carbon uptake and emissions in that region, which can then be used to improve global carbon models used for assessments.

- Increase the coverage of space-based maps of coral reef distribution by 25% beyond current estimates using remotely sensed imagery, which will provide a more complete data set that can be used to better assess the state of the health of coral reefs and serve as an improved baseline for future studies of their evolution.

How well can we predict future changes in the Earth system? The overarching purpose of Earth System Science is to develop the knowledge basis for predicting future changes in the state of the Earth and assessing the risks associated with such changes. A first step towards predicting the future of the Earth system is building a capability to simulate realistically the present state and its evolution both in the past few decades, and the future.

- Develop new analysis methods that integrate global observations from the complete suite of satellite (and conventional) weather measurements into a single, self-consistent analysis of water-related phenomena (diabatic heating by radiation and precipitation, water vapor and clouds, inference of water and energy fluxes and transports). This development provides for developing requirements for new satellite sensors and new data assimilation techniques leading to improved prediction capabilities.

- Deliver ensembles of forecast products (e.g., surface temperature, precipitation, upper level winds) to Operational agencies (e.g., National Center for Environmental Prediction (NCEP), International Research Institute (IRI). Forecasts with and without the use of satellite-based data will be used to document the impact of such remotely sensed data on forecast quality.

- Estimate and document potential predictability, based on multi-year reanalysis data and modeling, of regional climate variability in order to evaluate the relative contributions of seasonal-to-interannual and decadal climate variability on specific regions, with a focus on occurrence of major floods and droughts in North America and the Asian-Australian monsoon regions.

- Develop, implement, and document advanced cloud radiation and moist physics schemes in NASA climate models, and validate them against remotely sensed radiation data, in order to improve overall skill of climate model simulations of the global energy and water cycles.

- Quantify and document the role of different forcings (greenhouse gases, ozone, water vapor, solar irradiance, stratospheric and tropospheric aerosols) and unforced (chaotic) variability in determining the evolution of global climate over the past 50 years, to develop confidence in quantitative model predictions of future climate system.

BASIS OF FY 2003 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY

APPLICATIONS

Web Address: http://gaia.hq.nasa.gov/eseapps/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		Millions of Dollars)	
Research and Analysis – Applications	**41.1**	**--**	**--**
Commercial Remote Sensing	**51.1**	**--**	**--**
Education	**21.9**	**--**	**--**
EOS Fellowships and New Investigators	7.0	--	--
Education and outreach	9.9	--	--
GLOBE	5.0	--	--
Subtotal Without Education Agency Investment	**114.1**	**--**	**--**
Education Agency Investment	[10.3]	--	--
Total	**[124.4]**	**--**	**--**
Research and Analysis - Applications		**77.3**	**43.6**
Program Planning and Analysis		5.6	5.4
Applications Research		33.8	15.4
Applications Development		37.9	22.8
Education		**16.5**	**17.1**
Informal Education		**1.0**	**1.0**
Formal Education		**14.5**	**15.1**
(K-16)		2.1	7.1
GLOBE		5.0	--
Graduate Fellowships and New Investigators		7.4	8.0
Professional Education/Development		**1.0**	**1.0**
Outreach		**1.0**	**1.0**
Total		**94.8**	**61.7**

DESCRIPTION/JUSTIFICATION

The Applications Program serves the Nation by demonstrating practical uses of NASA sponsored ***observations*** from remote sensing systems and ***predictions*** from scientific research. NASA implements projects through partnerships with public, private, and academic organizations. These partnerships focus on innovative approaches for using Earth science information to provide decision support that can be adapted in applications nationwide.

The Applications Program transfers scientific knowledge, spatial information and data, and technical capabilities of Earth science between the research domain and the operational domain. The Applications, Education, and Outreach functions provide key linkages between NASA and its partners and constituencies in the public, private, and academic sectors.

PROGRAM GOALS

The program goal is to expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology. Applications are accomplished through projects that demonstrate productive uses of Earth system science results. Education is accomplished through programs that create and disseminate materials to stimulate interest in Earth science. Outreach is accomplished by contributing knowledge and leadership through participation in national and regional committees, workshops, studies, and other activities that involve multiple agencies and organizations.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology.

Strategic Plan Objectives Supported: Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private sector decision-makers; Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology.

Performance Plan Metrics Supported: Annual performance goals IIA1 and IIB1.

CONTENT

The Applications Program contributes to the NASA vision by enabling organizations and people in the public and private sectors to routinely deliver and use Earth science information that saves lives, improves the quality of life, and saves resources through improved decision making.

Specific elements of program contributions to the vision are:

- Provide enhanced and improved space-derived observation data to improve accuracy and duration of decision processes
- Provide the Federal agencies with appropriate data and information about Earth science (e.g., weather, climate, and natural hazards) to enhance existing, and develop new, products and services that can be delivered through state, local, and tribal organizations to serve citizens
- Provide valuable Earth science observations, data assimilation, research, and modeling in support of research needs for decision support and policy-making

NASA supports scientific research and policy by providing critical Earth system science observations, data assimilation, research results, and modeling as part of the USGCRP. NASA's unique space-based Earth observations also serve essential global change and solid Earth and natural hazard research needs of the National Science Foundation, USDA, Department of Defense (DoD), Department of Energy (DOE), Department of the Interior (DOI), Environmental Protection Agency (EPA), and Department of Health and Human Services and National Institutes of Health (HHS/NIH). NASA research and observations are employed in international scientific assessments by such organizations as the World Meteorological Organization, the Food and Agriculture Organization of the United Nations, the United Nations Environment Program, and the Intergovernmental Panel on Climate Change. The knowledge and information needs of organizations are expected to grow substantially in the coming decade, thus providing additional opportunities for NASA applications of remote sensing technologies, data, and programs.

In addition to supporting research, NASA works with USDA, NOAA, DoD, DOE, DOI, EPA, HHS/NIH, Federal Emergency Management Agency (FEMA), the Army Corps of Engineers (Corps), NIMA, Department of State, and others at the Federal level, and with a variety of state, local, and tribal organizations to demonstrate applications of Earth science. NASA and its partners extend research and developments in observations, processing, data assimilation, and modeling to serve national priority needs for a range of spatial information requirements for decision support.

The overarching objective is to bridge the gap between Earth system science research results and the adoption of data and prediction capabilities for reliable and sustained use in decision support. Related objectives are to:

- Simplify and integrate the use of Earth system science data and prediction results for adoption in national applications that enable improved decision-making.

- Enhance the availability, interoperability, and utility of ESE and U.S. private sector data sets, communications, computing, and modeling capabilities as inputs to serve specific applications and research.

- Produce prototypes, guidelines, assessments, and documentation of project results that are citizen-centered, results-oriented, and market-driven.

- Enable the project results to serve as benchmarks for policy and operational uses that benefit citizens through our Federal, state, local, and tribal partners.

A brief description of the program line items under Applications Research and Analysis is as follows:

1) **Program Planning and Analysis (PP&A)** - employs a systematic approach to identifying high priority applications that are evaluated using a specific set of prioritization criteria (NASA ESE Applications Strategy 2002).
2) **Applications Research** - evaluates the potential of Earth science and technology results and capabilities to address specific applications of national and global significance.
3) **Applications Development** - provides for the verification and validation of science and technology results to determine their feasibility for serving a specific application. The development activity employs system-engineering support to create prototypical applications to be evaluated in an operational setting. Validation involves the systematic and documented technical measurement, test, or evaluation of ESE and other (public agency or private) technologies, data, and/or models against standards, user-defined requirements, processes, and/or best practices.

The Education element includes

1) **Informal Education** - increases public awareness and understanding of how the Earth functions as a system and NASA's role in enabling development of knowledge of the Earth system.
2) **Formal Education** - enables the use of Earth science information for teaching and learning at all levels of education. Formal education includes continued training of interdisciplinary scientists at the graduate and early-career levels to support the study of the Earth as a system
3) **Professional Development** - builds capacity for productive use of Earth science results, technology, and information in resolving everyday practical problems.

Outreach encompasses the NASA participation in national and regional committees, workshops, task forces, and studies, including the Federal Geographic Data Committee, the Commercial Imagery Task Force, and the State Department Humanitarian Information Unit.

MAJOR APPLICATIONS RESULTS IN THE PAST YEAR

- In the AG 2020 with USDA and four growers associations representing 100,000 farmers, ESE is demonstrating the use of remote sensing technologies for improving the efficiency of crop productivity, reducing risks to crop health, and mitigating environmental impacts of excess fertilizers, pesticides, and herbicides.

- In support of the Aviation Safety program coordinated with the Federal Aviation Administration (FAA), the use of interferometric synthetic aperture radar (IFSAR) from the Shuttle Radar Topography Mission(SRTM) and data provided through the Science Data Purchase project from the EarthWatch/Intermap team was used to verify, validate, and demonstrate compliance with RTCA SC193 guidelines for aviation terrain specifications.

- Three ESE satellites tracked devastating wildfires in the western U.S. throughout the summer, providing data to the U.S. Forest Service and regional authorities. As a result, U.S. Forest Service is investing in direct broadcast receiving stations to rapidly acquire and disseminate timely data from NASA's Terra satellite throughout the western U.S.

- A Broad Agency Announcement (BAA) for state, local, and tribal government applications established 15 research and development projects in 13 states focused on the four applications themes of resource management, disaster management,

community growth, and environmental assessment. The purpose of these projects is to accelerate the adoption of Earth science and remote sensing solutions to enhance routine decision support in state, local, and tribal governments.

- The "Carbon Cycle Science and Related Opportunities in Biology and Biogeochemistry of Ecosystems and Applications" NASA Research Announcement established 14 projects including two focused on soil carbon sequestration. The purpose of these projects is accelerate and expand the use of Earth science and remote sensing related to carbon cycle, land use/land cover change, and terrestrial ecology.

- The Science Data Purchase project provided the global mosaic of Landsat data (circa 1990) from EarthSat Corporation that is supporting the State Department, USGS, USDA, and other agencies. The mosaic provided the foundation for the National Imagery and Mapping Agency (NIMA) to build the global land use/land cover (LULC) classification. A benefit of the LULC product is the water mask used in the production of the digital elevation model products being developed from SRTM. NASA has enabled the development of three very important global data sets.

- ESE supported FEMA in evaluating the use of lidar and IFSAR data to create digital elevation models (DEM) required for the Flood Map Moderation Program. FEMA has used knowledge gained from the partnership to create specifications for lidar and IFSAR-based DEM products to serve flood plain mapping.

- ESE partnered with the Department of Transportation (DOT) to implement a program in remote sensing applications that awarded four grants to university consortia to perform research on use of remote sensing and related technology to transportation issues including environmental management, infrastructure development, and emergency response. DOT also awarded eleven individual project grants in remote sensing applications.

- ESE funded research results enabled the creation of 52 stories of broad public interest that were the basis of over 20% of the major stories on Earth Systems Science covered in print and over the radio. The stories reached the audience of *Earth and Sky* science radio programming, providing information to over 3 million impressions per month in the U.S. alone.

- More than 400 educator training sessions where held across the country with more than 8,600 educators trained on ESE content. New undergraduate courses were created for pre-service education students at institutions, which previously did not teach Earth System Science. The Earth System Science Educators Alliance (ESSEA) continued to reach all 50 states by extending its membership to Alaska.

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2003

RESEARCH AND ANALYSIS – APPLICATIONS

Program Planning & Analysis (PP&A) employs systematic approaches to identify, select, and conduct applications that will serve the Nation by extending the benefits of Earth science and remote sensing technologies. ESE evaluates existing and planned capabilities in the public and private sector that are capable of supporting Earth science research as well as the readiness of

partnering agencies and organizations to integrate the Earth science and technology-based products and information for operational use. ESE develops an Applications Investment Portfolio on an annual basis that includes a suite of prioritized opportunities based on estimates of risk, payoff, and timelines.

There is a wide range of potential applications of ESE data and predictive capabilities. To systematically address application priorities in the national interest, ESE conducts its program planning in three stages. ESE considers candidate applications based on the extent to which they exhibit the following characteristics:

- Identified as a national priority by the Executive and/or Legislative branches
- Relevant to national program(s) of one or more Federal agencies or national organizations (of state and local agencies)
- Requirements validated (by other agencies) with the potential to be served by Earth science and remote sensing research and development results
- Significant societal and/or economic value in terms of clearly defined metrics, such as quality of life improvements, potential lives saved, and economic or resource savings

- Initial candidate applications to be reviewed using the prioritization criteria include:
    - Hurricane, flood, and earthquake prediction and assessment for community disaster preparedness
    - Weather and climate predictions for energy forecasting
    - Early warning systems of vector borne disease initiation and/or migration for human health
    - Land, air, and ocean monitoring of carbon sequestration indicators in support of carbon assessments
    - Global monitoring of air, land, and water quality parameters for homeland security
    - Weather prediction for transportation (aviation, maritime, and land-based)

Review of candidate applications take into consideration the potential impact. For instance, an independent assessment of the impact of improved weather forecasting is that the annual cost of electricity could decrease by at least $1 billion if the accuracy of 30-hour weather forecasts improved 1 degree Fahrenheit.

Applications Research focuses on discovery and testing Earth science and technology results and capabilities with the potential to contribute to applications of national and global significance. Plans through FY 2003 include:

- ESE is working with FEMA to research the potential of QuickScat, Terra, Aura, SRTM and other pertinent data sources to serve the information needs of the FEMA HAZUS model used to provide risk assessment and early warning for earthquakes, hurricanes and flooding.

- ESE is working with the Aviation Safety program at Langley Research Center and with the FAA to evaluate the potential of the Geostationary Infrared Fourier Transform Spectrometer (GIFTS) atmospheric sounder to provide key measurements enabling the prediction of more accurate weather patterns and turbulence for use in the Advanced Weather Information System (AWIN) and the Synthetic Vision Systems (SVS) to support improved efficiency and safety for air travel. The intended impact is to realize the projected annual savings of over $2 billion by operating aircraft using advanced Synthetic Vision Systems at just 10 airports in the U.S. (NASA report NS002S1 – Benefit Estimates of Synthetic Vision Technology, 2000)

- ESE will conduct assessment of the potential applications of the near-global SRTM 30-meter topographic data for global geologic and geomorphic process studies. The SRTM is providing the first continuous digital elevation model of 80% of the Earth's surface for better understanding the composition and processes on the Earth's surface. Candidate applications include better urban and infrastructure planning, environmental assessments, aircraft flight planning for aviation safety, and better natural hazards assessment and overall disaster management.

- ESE is working with USGS to develop and implement the Landsat Data Continuity Mission (LDCM) to support the long-term availability of moderate resolution imagery with emphasis on transitioning to the provide sector sources.

- ESE plans to work with EPA to develop projects in identifying indicators for mapping and monitoring pollutants in the air. The mapping project will include a workshop with USGS on the use of LIDAR data for water resource mapping.

- Completion of Southern California Integrated GPS Network (SCIGN) will provide a near real time capability for the evaluation of crustal deformation associated with earthquakes. ESE plans to enable the posting of ground deformation information within hours of an earthquake as opposed to the months required for traditional post-seismic GPS surveys. ESE plans to develop the algorithms and technology of the SCIGN network to improve its utility to both the science community and to civilian, municipal, county, and state government for risk assessment and disaster management activities.

- ESE plans to test an automatic volcano eruption detection procedure using EOS Terra data sets that will automatically detect eruptions and monitor and track plumes, and will distribute the resulting procedures into joint NASA and Federal Aviation Administration (FAA) aircraft routing and warning systems efforts. This information will help promote safe air travel. ESE will continue to work with USGS and other International volcano monitoring programs on the implementation of low-cost GPS arrays and the use of interferometric SAR data for the development of warning systems regions vulnerable to explosive volcanic eruptions.

- ESE will continue to support Homeland Security activities through working with the DOD, USGS, NIMA, and Office of Homeland Security by evaluating EO-1, Terra, Aura, SRTM, and other mission support as well as atmospheric, oceanic, hydrologic, and terrestrial models for air, water, and land quality assessments.

- ESE will continue to contribute to early warning systems for human health through working with the National Institutes of Health and the Environmental Protection Agency in extending the results of science developments in environmental conditions for the initiation and transport of infectious diseases supported by measurements from the Terra, QuickScat, and Aura missions.

Applications Development involves field-testing science and technology results in a realistic setting to determine their fitness for a target application, and creating proto-typical applications in pre-competitive yet near real operational settings. The planned FY 2002 and FY 2003 demonstrations will include:

- The use of Earth science and remote sensing technologies to the agricultural community through continuation of the agricultural initiative with USDA (Ag 20/20) that leads to a joint solicitation and total award of 15 - 20 partnerships, with 4 - 6 competitively selected partnerships with cotton, corn, wheat, and soybean growers. These partnerships will focus on improvements in farm management practices utilizing geospatial technologies that can lead to increases in efficiencies of food and fiber production.

- ESE will provide state, local, and tribal government access to scientific results through demonstrations conducted in partnership with key organizations. Demonstrations will be provided through venues arranged by the National States Geographic Information Council (NSGIC), Western Governors Association (WGA), International City Managers Association (ICMA), Aerospace States Association (ASA), National Association of Counties (NACO), Mid-America States Consortium and National Conference of State Legislatures (NCSL). Regional workshops will be held to increase communication and expand collaboration with and among the State and Local government user communities. The workshops will demonstrate ESE data products and science results to the state and local government community for their use in practical decision-making.

Applications Verification and Validation - Involves the systematic and documented technical measurement, test, or evaluation of ESE and external (pubic agency or private) technologies, data, models with the objective of validating these against standards, user defined requirements, processes, and best practices. The planned FY 2002 and FY 2003 validation developments will include:

- ESE is developing, fostering, and promulgating formats, standards, and protocols for calibration, validation and dissemination of geospatial data both national and internationally. ESE is working with the Federal Geographic Data Committee (FGDC) and the Geospatial One-Stop e-government initiative.

- ESE supports a Joint ESE and American Society for Photogrammetry and Remote Sensing (ASPRS) multi-disciplinary team to develop Digital Imagery Mapping Guidelines and refinement of draft Digital Imagery Standards and digital certification techniques. This team provides a lead role in the development of LIDAR and Thermal guidelines.

- ESE is a partner in the Joint Committee on Imagery Evaluation (JACIE) support to the USGS and NIMA in performing systems characterization activities including working with the Department of Energy (DOE) on the Multi-Thermal Imager, evaluations of commercial data products including DigitalGlobe QuickBird and Resource 21 data simulations and validation, and future missions including Landsat Data Continuity Mission (LDCM) and Tropospheric winds missions trade studies.

EDUCATION

Education includes three program areas to accelerate the packaging and delivery results of NASA Earth science to the educational community: (1) Informal Education, (2) Formal Education, and (3) Professional Development. These three elements are integrated and coordinated using educational themes that will unify content, topics and messages across these areas. All ESE educational efforts (i.e., those associated with flight projects, field campaigns, research grants, cooperative agreements, and Center activities) are

aligned using these themes. This thematic integration and coordination is enhanced by a partnership with the Digital Library for Earth System Education funded by the National Science Foundation that enables sharing of content among educational audiences.

- In FY 2003, ESE will continue its activities in Informal Education focused on broad public awareness and understanding of the Earth as a system, the related technologies and applied uses, and the relevance to our daily lives via broadcast media (the mode by which most Americans learn about science and technology). Efforts will focus on activities to improve the awareness of ESE content within the museum community; e.g., workshops, presentations and exhibits at conferences, and the Crosscutting partnership with NSF will focus on access and usability of content by this community.

- The two pilot efforts with the Girl Scouts are directed to increase cognizance and aptitude of Earth science to this target audience. The pilots focus on scaling-up in both leader training and badge endorsement at the national level. Pilot efforts will begin in FY 2003 with the National 4-H Council.

- In FY 2003, NASA will continue conducting workshops to train teachers in the use of Earth Science education products, and coordinate with the education organizations to affect systemic integration of ESE content into established curricular materials and learning venues. The K-16 Formal Education will place particular focus on systemic improvement activities by identifying and filling content/concept gaps in the array of curriculum support materials, and on establishing a scalable and affordable approach to educator enhancement. GLOBE will be integrated into the K-16 Formal Education with increased emphasis on systemic improvement so that the numerical performance goals of GLOBE migrate from a focus on schools to a focus on educators, classrooms and district-wide participation in science learning.

- ESE will continue its annual solicitation and selection of graduate student fellowships, and also support at least 30 active early-career education research grants in Earth system science.

- ESE will continue new efforts in Professional Development, focused on: 1) training of professionals currently in the workforce who are allied with a funded applied applications activities at the federal, state and local level (e.g., in-service professionals), and 2) training of undergraduates in key applied fields so that they enter the marketplace with discipline specific skills in applied remote sensing (measurement, analysis, interpretation)

OUTREACH

ESE participates in multi-participant organizations at the international, national, regional, state, local, and tribal levels to contribute Earth science knowledge and leadership. ESE provides consistent support to committees, task forces, delegations, workshops, studies and other organized activities that facilitate and accelerate the transfer of information to serve the respective communities.

BASIS OF FY 2003 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY

TECHNOLOGY PROGRAM

Web Address: http://esto.nasa.gov/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
Technology Infusion	78.2	80.0	68.3
New Millennium Program	35.0	35.8	28.0
Advanced Information Systems Technology	15.4	9.5	9.8
Advanced Technology Initiatives	12.8	19.7	8.5
Instrument Incubator Program	15.0	15.0	22.0
Computational technologies (formerly HPCC)	21.7	21.8	19.0
Total	99.9	101.8	87.3

DESCRIPTION/JUSTIFICATION

The Earth Science advanced technology program is focused on development of key technologies to enable our future science missions by reducing their development time and cost.

PROGRAM GOALS

The Earth Science Technology program develops and demonstrates technologies that will enable future missions, reduce the cost of future missions, and enable a maximum 3-year acquisition timeline for flight and ground systems. The program consists of five major areas that will lead to the successful and timely development and infusion of technologies into future programs.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Develop and adopt advanced technologies to enable mission success and serve national priorities.

Strategic Plan Objectives Supported: Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation; Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data.

Performance Plan Metrics Supported: Annual Performance Goals as shown in Annual Performance Plan: IIIA1 IIIB1, IIIB2.

TECHNOLOGY PROGRAM CONTENT

New Millennium Program

The New Millennium Program (NMP) validates innovative measurement concepts, associated enabling instrument technologies and space platform technologies required for future missions. NMP identifies, develops, and selects technologies that required space validation before these new technologies can be flown on science or operational missions. The NMP reflects a commitment to capitalize on U.S. investments in advanced technologies by reducing the risk to the first users through validation of the technologies in space. The NMP focus is on development of new technology to meet the scientific needs of the next few decades and to reduce future Earth science mission costs through focused technology demonstrations for Earth orbiting missions. The ESE has joined the Space Science Enterprise (SSE) in the management of NMP in order to realize the benefits from common work in core technology development projects and specific spacecraft and instrument studies. The program identifies and demonstrates advanced technologies that reduce cost and improve performance of all aspects of missions for the 21st century, (i.e., spacecraft, instruments, and operations). The program objectives are to spawn "leap ahead" technology by drawing the best capabilities available from several sources within the government, private industries, and universities via open competition. These low-cost, tightly controlled developments, Earth Observing (EOS) projects, will take more risk in order to demonstrate the needed technology breakthroughs and thus reduce the risk of using that technology in future science missions. Missions will be selected based on their ability to meet the science needs of the future by innovative technology that would also decrease the cost and improve the overall performance of Earth science missions.

Advanced Information Systems

Advanced Information Systems Technology (AIST) develops advanced end-to-end mission information system technologies to capitalize on the technological advances of future missions. Information technology advances play a critical role in collecting, handling, and managing very large amounts of data and information in space as well as on the ground. The objectives of the ESE AIST program are to identify, develop, and (where appropriate) demonstrate advanced information system technologies which:

- Enable new Earth observation measurements and information products,

- Increase the accessibility and utility of Earth science data, and
- Reduce the risk, cost, size, and development time of OES space-based and ground-based information systems.

Advanced Technology Initiative

Advanced Technology Initiatives (ATI) focuses and refines ESE technology requirements and advance key component and subsystem technologies required for the next generation of exploratory and systematic space-based missions. Investment strategies within the ATI are structured to develop key technologies focused on enabling future ESE missions, from advanced concepts, through technology advancements up the Technology Readiness Level (TRL) ladder, to readiness for infusion into future missions. Emphasis is being placed on developing new capabilities for Earth science sensors; integrated, autonomous, self-calibrating instruments and visionary architectures for future Earth Science observing systems.

Instrument Incubator Program

The Instrument Incubator Program (IIP) develops new instruments and measurement techniques at the system level. The IIP is expected to reduce the cost and development time of future scientific instruments for Earth science. The instrument incubator program aggressively pursues emerging technologies and proactively closes the technology transfer gaps that exist in the instrument development process. The program takes detectors and other instrument components coming from NASA sponsored fundamental technology development projects and other sources, and focuses on combining them into new instrument systems. This includes key follow-on instruments that will provide measurements in support of the decadal Science Research Plan.

Computational Technologies (Formerly HPCC)

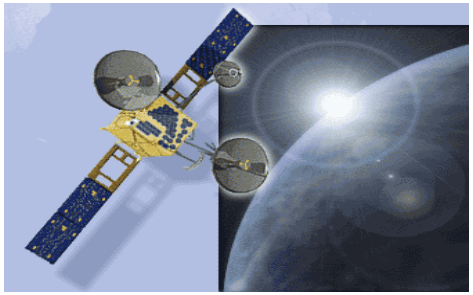
The goals of Computational Technology (CT) program are to accelerate the development, application, and transfer of high performance computing technologies to meet the engineering and science needs of the NASA Earth science program. The CT investment will focus on advanced developments of particular interest in Earth and space science. CT develops and applies scalable computational technologies and software tools to further the development of a suite of multidisciplinary models, simulations, and analyses of data products. The goal is to provide scalable global simulations coupling many disciplines and to simulate complex multiple-scale problems associated with space science. High resolution, multidisciplinary models are important for their predictive value and for their ability to extrapolate beyond our ability to measure and observe systems directly. CT research increases NASA's capability to produce, analyze, and understand its science and mission data while reducing the investment in money, time, and human resources.

BASIS OF FY 2003 FUNDING REQUIREMENT

NEW MILLENNIUM PROGRAM Missions Funded in the FY 2003 Budget

NMP Earth Observing 3 (Eo-3)

Web Address: http:// gaia.hq.nasa.gov/ese_missions/



The EO-3 Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) will validate a new low-cost, high performance approach to atmospheric sounding for weather prediction. This mission is intended to demonstrate technologies required to measure atmospheric temperature within 1 degree K and 1 Km vertical resolution from geostationary orbit for the first time. Such a measurement will enable significant improvements in accuracy of short-term weather forecasts, as well as enable measurements of atmospheric chemical composition from this orbit for the first time. In addition, GIFTS will enable advanced technologies including large area focal-plane array, new data readout and signal processing electronics, and passive thermal switching. These technologies which will be used for measuring temperature, water vapor, wind and chemical composition with high resolution in space and time. EO-3 is being planned as a partnership with the Office of Naval Research in the Department of the Navy (DON) and the NOAA. This partnership will include provision of funding for spacecraft and launch for the mission, validation of the data products by the National Weather Service, investment in technology infusion for the next generation of NOAA operational sounders, as well as transferring the GIFTS operation to extended Indian Ocean observations. The details of this partnership are still being negotiated. The current plan for the launch of the mission is October 2005. The launch is to be provided by the Air Force Space Test Program (STP).

Objectives:

- Validate advanced technologies for new low cost, geosynchronous, optical remote sensing systems.
- Provide an altitude-resolved water vapor winds measurement capability for revolutionary improvements in operational weather observation and prediction

Funding (Millions of Dollars):

FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
19.0	30.0	22.3

Critical New Technologies Demonstrated:

- Imaging Interferometer – demonstrate a cryogenic Michelson interferometer optimized for sounding applications
- Long-wave Focal Plane Array (LFPA) and Advanced cryogenic cooling – demonstrate a large area detector array and readouts as well as associated miniaturized cryo-coolers
- High speed signal processing – demonstrate high-speed, ultra-low-power signal processing
- Data compression – demonstrate a radiation hardened vector processor for on-board real-time signal processing and data compression
- Autonomous pointing and control – demonstrate autonomous pointing and control systems for precise imaging stabilization and feature tracking
- Low power radiation tolerant microelectronics – demonstrate radiation protection and ultra-low-power electronics
- Lightweight structures and optics - demonstrate lightweight optics and structures to minimize instrument mass

Key Formulation Milestones:	**FY 2003 BUDGET DATE**	**FY 2002 BUDGET DATE**	**BASELINE DATE**	**CHANGE (FY02-FY03)**	**COMMENT**
PDR	March 2000	--	March 2000		
CDR	April 2002	--	April 2002		
Instruments delivered	June 2004	--	June 2004		
Launch Readiness Date	September 2005	--	September 2005		

Lead Center: LaRC	**Other Centers:**	**Interdependencies:** Navy and NOAA
Subsystem	**Builder**	
Spacecraft	TRW & U.S. Navy	
Sensor Subsystem (optical)	Space Dynamics Laboratory, UT	
Electronics Subsystem	LaRC	
Instruments	**Builder**	**Principle Investigator:** Dr. William Smith at LaRC
Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS)	Space Dynamics Laboratory, and LaRC	
Launch Vehicle: Delta 7320	**Tracking/Communications**: U.S. Navy	**Data Handling:** NOAA

MAJOR TECHNOLOGY RESULTS IN THE PAST YEAR

Outlined below are FY 2001 technology achievements that benefit ESE by enabling future missions, reducing the cost of future missions, or that will enable a 3-year acquisition timeline for future flight and ground systems.

- The launch and activation of the Earth Observing 1 (EO-1) technology demonstration satellite, the first ESE New Millennium Program mission. One of the main mission objectives was to demonstrate new and cheaper technologies compared to the current standard Landsat series. In doing so, EO-1 included new instruments for better characterization of the Earth, such as the world's first space-based hyper spectral sensor. This sensor will open new frontiers for the next great science and applications opportunities in Earth remote sensing. At one-quarter the mass and one-third the cost of traditional Landsat satellites, EO-1 demonstrated our ability to produce Landsat-like imagery at a fraction of the previous Landsat mission costs with better performance. EO-1 flies in formation with our EOS Terra satellite, Landsat-7 and a joint U.S./Argentina satellite to demonstrate the satellite constellation concept in which the combined capabilities create a super-satellite. Most importantly, several of the EO-1 technologies, once validated, will be turned over to the private sector for commercial development.

- 9 of 26 (35%) IIP technologies were advanced at least one Technology Readiness Level. This exceeded the goal of 25%.
- Two advanced information systems technologies and concepts for processing, archival, access, and visualization of ESE data was developed. Researchers selected under a Cooperative Agreement Notice entitled, "The Increasing Interoperability and Performance of Grand Challenge Applications in the Earth, Space, Life, and Microgravity Sciences" (CAN-00-OES-01) are working on the multi-year project seeking to integrate various climate models into one framework global climate model.
- Developed seven technologies (including one new instrument) to demonstrate in space with the third New Millennium Earth Observer (EO-3) satellite GIFTS. The technologies GIFTS demonstrates will enable improvement in the general capability of future remote sensing satellites, as well as reductions in their cost. Additionally, the technologies GIFTS tests in space will also help revolutionize the observation and prediction of our weather, enabling scientists and meteorologists to forecast the weather with a new level of accuracy in the future.
- At least two technology developments were transferred to a commercial entity for operational use. NASA, other federal agencies, and commercial partners are working to validate all nine of the technologies aboard EO-1. As part of that partnership, after the technologies have been validated, the commercial partners can market them. The EO-1 X-Band Phased Array Antenna (Boeing and Lewis) and the EO-1 Carbon-Carbon Radiator (Amoco Polymers, BF Goodrich, Lockheed Martin) were validated and transferred to commercial entities.
- A breakthrough in climate modeling was announced in July 2001. Using the newly developed 512-node silicon graphic supercomputer, ESE researchers were able to simulate more than 900 days of the Earth's climate in one day of computer time. Previous capability had been limited to the simulation of 70 days. This supercomputer is of great value for Earth scientists because it enables more accurate computer models of climate change using global satellite observation data collected by NASA. For example, in FY 2001, researchers were able to demonstrate experimental seasonal climate predictions using ESE data sets from the TOPEX/Poseidon, SeaWiFS, TRMM, and Terra satellites. The combination of a faster computer,

more accurate climate models, and the use of more global satellite observations will result in improved accuracy of climate prediction for economic and policy decision makers. Ultimately, ESE would like to develop the supercomputing capability to integrate all the components of the climate system into models of the living, breathing Earth.

- Demonstrating the use of ESE science and technology to government officials by hosting five workshops around the U.S. Over 550 decision-makers representing nearly every state attended these workshops. A survey conducted during the workshops found that 35% of respondents had never used satellite data. A follow-up survey after the workshops demonstrated that the number fell to 20%. This effort supported the ESE goal of improving access to and understanding of remote sensing data by economic and policy makers.

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2003

FY 2002 and FY 2003 technology performance goals are defined in the FY 2002 and FY 2003 ESE Performance Plans. Stated performance goals are listed below followed by a sampling of major activities planned in each program area.

- Annually advance 25% of funded technology developments by one Technology Readiness Level (TRL).

- Annually mature at least three (3) technologies to the point where they can be validated in space or incorporated directly into a science and/or operational project(s).

- Annually infuse at least one (1) technology development to a commercial entity; into a remote sensing or in-situ project; or into the ES information systems infrastructure.

- Annually establish at least one (1) joint agreement with a program external to NASA's ESE that results in the inclusion of at least one new ESE technology requirement.

New Millennium Program

- Mission Confirmation for the GIFTS program is anticipated in FY 2002

Advanced Information Systems Technology

- The annual technology performance goals for FY 2002 and FY 2003 require the accomplishment of activities from the first AIS NRA closed on January 25, 2000. Thirty proposals were selected for award covering a variety of topics ranging from satellite on-board processing, data collection and analysis, information transmission and wireless networks, to satellite platform control and flight operating systems. Technology Infusion plans active management of these tasks to insure optimum technology advancement

- The near-term investment strategy for AIS continues the Advanced Prototyping System (APS) effort in support of EOSDIS, the next generation DIS, and other ESE ground system development technology needs. Prototyping is accomplished through the Quick Response System (QRS), and the objectives are to leverage technologies to reduce costs and enhance the use of EOS data, and to explore technologies to enable the next generation DIS. Technologies are currently categorized into five areas: science processing, storage management, interactive access, data server access and infrastructure, and open distributed architecture.

Advanced Technology Initiative

- In FY 2002 ATI will issue an NRA to address key component technologies to support measurements required in the ESE Science Plan.

- In FY 2002 and FY 2003 activities from the first ATI instrument solicitation awarded in January 2000 will begin to mature. The 23 awards address a broad range of technology categories to reduce the risk, size and development costs for Earth observing instruments and enable new Earth observation measurements. Awards were made for instrument components in active and passive optical, active and passive microwave as well as advanced electronic components for future ESE instruments.

Instrument Incubator Program

- An NRA was issued in May 2001 and closed in July 2001 that solicited technology developments in the focus areas of lasers and lidar systems, passive microwave radiometers, and radar systems. NASA received 64 proposals of which 11 have been selected and will be under contract in FY 2002. Most of these IIP projects represent efforts to reduce the cost, size, mass, and resource use of current measurement approaches. Several will enable or improve measurements that cannot be made satisfactorily today. The projects have start dates ranging from October 2001 to January 2002. The projects range in length from 2 ~~1~~ to 3 years and will end between November 2004 and February 2005.

  The next solicitation will focus on the next generation of systematic and exploratory instruments to be launched in the 2008 to 2010 timeframe. By mid-2002 the first set of Incubator projects will be complete, the second set will be underway, and the post-2002 mission composition will be much better defined. Gaps in measurement technology will be analyzed at that time to target specific measurement areas. The emphases may include stratospheric chemistry, further airborne in-situ measurements, cloud and aerosol characterization, and ice sheet mass balance measurements.

- For FY 2002 a project was started to address laser transmitter technologies. This project grew out of concern that there are no lasers as active sources for space-based remote sensing that have been space qualified for long-term science measurements. Presently, the risks inherent in developing these technologies have been born by science programs. The intention of this project is therefore to mitigate risks in certain areas so that programs such as IIP can further the maturation of the instruments prior to science infusion. The project will invest in several critical areas:

- Advancing transmitter technologies to enable ESE science measurements (tropospheric ozone, water vapor, winds, and altimetry)
- Development and qualification of space-based laser diode arrays
- Advancing nonlinear wavelength conversion technology for space-based lidars

Computational Technologies

- Eleven diverse scientifically important Investigations were selected in FY 2001 through a Cooperative Agreement Notice and full Headquarters peer review whose code products will be used by other groups, especially through identifiable provider/customer relationships. Investigator teams are working to advance the performance of specific application codes and expand their reusability and interoperability with other related codes within self-defined multidisciplinary scientific communities. Development of an Earth System Modeling Framework and movement of a critical mass of the national Earth system modeling community to it is a top priority. Desired outcomes include fostering reusability among software components and portability among high-end computing architectures; enabling of software exchange between major centers of research; structuring of systems for better management of evolving codes; and reduction in the time required to modify research application codes.

BASIS OF FY 2003 FUNDING REQUIREMENT

Construction of Facilities

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
Construction of Facilities (CoF)	--	--	3.4
Total	--	--	3.4

DESCRIPTION/JUSTIFICATION

Construction of a Flight Projects Center Phase 2 at JPL. Refer to Co F Section for Project description and justification. This CoF project is funded by ESE (15%) and the Space Science Enterprise (85%) as the primary beneficiaries.

In the Initial FY 2002 Operating Plan Change Request, $2.5M has been allocated across numerous JPL related activities. It is anticipated that the FY 2003 funds will be allocated across numerous JPL related activities as well.

BASIS OF FY 2003 FUNDING REQUIREMENT

MISSION OPERATIONS

Web Address: http://gaia.hq.nasa.gov/ese_missions/

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
Mission Operations	**57.8**	**47.6**	**28.8**
(Upper Atmosphere Research Satellite)	10.6	2.9	--
(Total Ozone Mapping Spectrometer)	6.9	5.0	2.7
(Ocean Topography Experiment (TOPEX)	6.7	6.6	0.7
(Tropical Rainfall Measuring Mission)	14.7	13.8	13.5
(Earth Science)	18.9	19.3	11.9
Earth Science Operations	**--**	**--**	**219.0**
Total	**57.8**	**47.6**	**247.8**

DESCRIPTION/JUSTIFICATION

This program supports the observations and data management portion of Earth science activities. Operations, Data Retrieval and Storage (ODRS) provides the data and data products from EOS precursor missions, including the UARS, TOPEX, TOMS, NSCAT, and TRMM. These data and data products are required to understand the total Earth system and the effects of humans on the global environment.

In FY 2003, the operations of EOSDIS will continue, the ECS development contract will end and a new EOSDIS Maintenance and Development (EMD) contract will be established. Starting in FY 2003 the EOSDIS budget has been separated into two parts; Development and Operation. This change was required in order to reflect the operational nature of most of EOSDIS. This realignment reflects the true nature of the operations type activity. We have therefore transferred the appropriate elements into Earth Science Operations to reflect the transition from development to operations starting in FY 2003. This element also includes Space communications ground network activity transferred from the HEDS account. The ESE is accepting NASA-wide management and funding responsibility for space communications data services, systems upgrades, and space communications technology for the ground network component of spell Space Operations Management Office (SOMO). This streamlines SOMO management and enables more emphasis on the direct role of the customer in defining, weighing cost vs. benefit, and paying for the services as needed.

The objectives of the mission operations program are to acquire, process, and archive long-term data sets and validated data products. These data sets support global climate change research in atmospheric ozone and trace chemical species, the Earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology. Funding provides for operating spacecraft such as UARS, TOPEX, ERBS, TOMS, TRMM, and processing of acquired data.

Under the Earth Science element, Alaska Synthetic Aperture RADAR (SAR) Facility (ASF) missions includes the European Space Agency Remote Sensing Satellite (ERS-1-2), the Canadian (RADARSAT) for new acquisitions, Japanese Earth Remote Sensing Satellite (JERS-1), and RADARSAT mission for historical and archival missions. Key participants involved in the ASF include the European Space Agency, Japan NASDA, Canadian Space Agency, NASA/Goddard Space Flight Center, NASA/Wallops Flight Facility (WFF), the Jet Propulsion Laboratory (JPL, the Ohio State Byrd Polar Research Center, and University of Alaska which hosts the ASF). SAR data acquisition and usage involved countries throughout the world, including, Italy, Saudi Arabia, China, Australia, France, Canada, Brazil, the United Kingdom, and Germany.

CURRENT/PROJECTED MISSIONS IN OPERATION:

The following is a comprehensive list of all Earth Science spacecraft that are, or are expected to be, operational at any time between January 2001 and September 2003.

MISSION	LAUNCH DATE	MISSION END	Mission Objectives/Status
SORCE	**July 2002**	**July 2007**	Continuation of measurement of both solar and stellar irradiance.
AQUA	**NET March 2002**	**March 2008**	Variety of measurements related to the Earth/atmosphere system, including atmospheric temperature and humidity profiles, clouds, precipitation, snow cover over land, sea ice cover over ocean, sea surface and land-surface temperatures, soil moisture and Earth's radiation budget.
GRACE	**March 2002**	**March 2007**	GRACE will utilize an advanced microwave ranging system between two identical formation flying spacecraft to measure the Earth's gravitational field to an unprecedented accuracy.
SAGE III	**December 10, 2001**	**December 2004**	Measurement of both solar and lunar occultation to measure vertical profiles of aerosols, ozone, and other gaseous constituents of the atmosphere.
JASON	**December 7, 2001**	**December 2006**	Follow On mission to Topex/Poseidon. Extend ocean topography measurements into the 21stt century
ACRIM	**December 20, 1999**	**December 2004**	Providing for the continuation of the long-term, quantitative understanding of the solar forcing of Earth's climate.
Terra	**December 18, 1999**	**December 2004**	100% operational. Terra is processing 200 gigabytes of data per day. Obtain information about the physical and radiative

			properties of clouds and aerosol; exchange of energy, carbon and water between the air, land, and water, as well as measurements of important trace gases in the atmosphere and volcanology.
QuikScat	**June 19, 1999**	**September 2002**	Instruments to collect sea surface wind data. Is filling the gap in such critical data between ADEOS 1, which failed in June 1997 after seven months on-orbit, and ADEOS II.
Landsat-7	**April 15, 1999**	**April 2004**	NASA operated the satellite through FY 2000. 100% operational. Processing 250 scenes/day. USGS assumed operation and funding responsibility beginning October 1, 2000. Making high spatial resolution measurements of land surface and surrounding coastal regions used for global change research.
SeaStar / SeaWiFS / Ocean Color	**August 1997**	**N/A**	This is a data buy from Orbital Science Corporation (OSC) and the operation of the spacecraft is an OSC responsibility. 100% operational. Processing 41,700 Bytes/second.
TRMM	**November 1997**	**November 2000** Operations funded thru Mid FY 2004	Launched with a 3-year mission life. All operations are nominal, except the CERES instruments, which is non-operational due to an anomaly with Data Acquisition Assembly Converter. 95% operational. Processing 250,000 Bytes/second.
TOMS FM3	**July 1996**	**July 2001** Operations funded thru Mid FY 2004	The TOMS-EP spacecraft was launched in July 1996 with an expected 5-year mission life. It has completed its primary mission phase. The first global ozone image was produced and released September 13, 1996. Automated processing and distribution of science products began September 20, 1996 and Internet distribution started on October 7, 1996. 100% operational. Processing 250 Bytes/second.
ERBS/ERBE/SAGE II	Oct. 1984, December 1 984 and September 1986	Operations funded thru FY 2002	The ERBS spacecraft launched in October 1984. It has gone well beyond the expected mission life. 67% operational. SAGE processing 1,600 Bytes/second. ERBE processing 200 Bytes/second. The ERBS mission is planned for decommissioning by the end of FY 2002.
TOPEX	**August 1992**	**August 1995** Operations funded thru	Launched with an expected 3-year mission life. The extended mission is now in its tenth year of mission life. Satellite and sensors are 100% operational, with continuous science date return of >99% Cross-calibration and tandem

		FY 2002	mission activities will commence following the launch of Jason-1. Processing 2000 Bytes/second
UARS	**September 1991**	**September 1994** Operations funded thru FY 2002	Launched in September 1991 with an expected three-year mission life. It has gone well beyond the expected mission life providing data to support improvements monitoring the processes that control upper atmospheric structure and variability, the response of the upper atmosphere to natural and human-induced changes, and the role of the upper atmosphere in climate variability. The spacecraft is transitioning to real-time operations due to a second recorder failure in November 1999. 95% operational. Processing 4,000 Bytes/second. The UARS mission is operating in the "data trace ability" mode and is planned for termination effective September 30, 2002.
Alaska SAR Facility Missions: ERS-1 (launched 1991) JERS-1 (launched 1992) ERS-2 (launched 1995) RADARSAT (launched 1995) ADEOS (launched 1996) ADEOS-2 (launch 2002) Antarctic Mapping Mission (2001)			The Alaska SAR Facility is a ground receiving station and data processing station, which now supports ERS-2 and RADARSAT operational missions and continues to support ERS-1, JERS-1, ERS-2, and RADARSAT historical and archival missions.

At least 90% of the total on-orbit instrument complement will be operational during their design lifetime.

BASIS OF FY 2003 FUNDING REQUIREMENT

INVESTMENTS

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
	(Millions of Dollars)		
Minority University Research & Education Program (MUREP)*	8.8	--	--
Education**	1.5	--	--
Total	10.3	--	--

* FY 2000 and FY 2001 MUREP covered in Applications, Commercialization and Education (ACE).
** In FY 2002, this activity has been transferred to the Agency Education program.

PROGRAM GOALS

The above funding requirements represent the ESE budget contribution to the Minority University Research and Education Programs (MUREP) and the Education Program.

STRATEGY FOR ACHIEVING GOALS

The ESE investments in higher education institutions include federally mandated outreach to the Nation's Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs), including Hispanic-Serving Institution and Tribal Colleges and Universities. This outreach is achieved through a comprehensive and complementary array of strategies developed in collaboration with the Office of Equal Opportunity Programs. These strategies are designed to create a broad-based, competitive aerospace research capability within Minority Institutions (MI's). This capability fosters new aerospace science and technology concepts by integrating ESE related cutting-edge science and technology concepts, practices, and teaching strategies into MI's academic, scientific, and technology infrastructure. As a result, increasing the production of more competitive trained U.S. students underrepresented in NASA-related fields who, because of their research training and exposure to cutting-edge technologies, are better prepared to enter graduate programs or the workplace. Other initiatives are focused on enhancing diversity in the ESE programs and activities. This includes exposing faculty and students from HBCUs and OMUs, and students from under-served schools, with significant enrollments of minority students, to the ESE research efforts and outcomes, educational programs, and activities. To support the accomplishment of the ESE mission, these programs are implemented through NASA Centers and JPL. The Centers and JPL support the MUREP through use of their unique facilities, program management and grant administration, and commitment of their personnel to provide technical assistance and assist in other facets of program implementation. Extensive detail as to how this funding is utilized is located under the MUREP portion of the budget.

In carrying out its Education Program, NASA is particularly cognizant of the powerful attraction the ESE mission holds for students and educators. The unique character of Earth Science exploration, scientific, and technical activities has the ability to captivate the imagination and excitement of students, teachers, and faculty, and channel this into an investment which support NASA's Education Program.

In fulfilling its role to support excellence in education as set forth in the NASA Strategic Plan, the NASA Education Program brings students and educators into its missions and its research as participants and partners. NASA provides the opportunity for educators and students to experience first hand involvement with ESE scientists and engineers, facilities, and research and development activities. Examples of such opportunities include the Learning Technologies Program, a new Undergraduate Internship Program, and the Graduate Student Researchers Program. The participants benefit from the opportunity to become involved in research and development endeavors, gain an understanding of the breadth of Earth Science activities, and return to the classroom with enhanced knowledge and skills to share with the entire education community. Detail as to how this funding is utilized is located under the NASA Education portion of the budget.

BASIS OF FY 2003 FUNDING REQUIREMENT

EARTH SCIENCE INSTITUTIONAL SUPPORT

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
			(Millions of Dollars)
Research and Program Management (R&PM)	**249.9**	**267.9**	**296.7**
Personnel and related costs	179.4	173.5	195.1
Travel	5.3	5.2	5.6
Research Operations Support (ROS)	65.2	89.2	96.0
Construction of Facilities (CoF) - (Non-Programmatic)	**27.8**	**20.5**	**21.2**
Total.....	**277.7**	**288.4**	**317.9**
Total Direct and Indirect Civil Servant Full-Time Equivalent (FTE) Work Years	**1,913**	**1,747**	**1,848**

PROGRAM GOALS

The two primary goals of this budget segment are to:

1. Acquire and maintain a civil service workforce that reflect the cultural diversity of the Nation and, along with the infrastructure, is sized and skilled consistent with accomplishing NASA's research, development, and operational missions with innovation, excellence, and efficiency for the ESE.

2. Ensure that the facilities critical to achieving the ESE are constructed and continue to function effectively, efficiently, and safely, and that NASA installations conform to requirements and initiatives for the protection of the environment and human health.

RESEARCH AND PROGRAM MANAGEMENT (R&PM)

Program provides the salaries, other personnel and related costs, travel and the necessary support for all administrative functions and other basic services in support of research and development activities at NASA installations. The salaries, benefits, and supporting costs of this workforce comprise approximately 66% of the requested funding. Administrative and other support is

approximately 32% of the requests. The remaining 2% of the request are required to fund travel necessary to manage NASA and its programs.

The FY 2002 funding estimate for ROS includes $4.5M provided in the Emergency Supplemental to enhance NASA's security counterintelligence and counter-terrorism capabilities. The FY 2003 funding estimate is $2.3M.

CONSTRUCTION OF FACILITIES (CoF)

Budget line item provides for discrete projects required for components of the basic infrastructure and institutional facilities and almost all are for capital repair. NASA facilities are critical for the ESE, to sustaining the future of aeronautics and advanced space transportation, which both support military and private industry users. NASA has conducted a thorough review of its facilities infrastructure, finding that the deteriorating plant condition warrants the need for a steady repair and renovation rate to avoid safety hazards to personnel, facilities, and mission, and that some dilapidated facilities need to be replaced.

ROLES AND MISSIONS

The detail provided here is for the support of the ESE institutions - Marshall Space Flight Center, Stennis Space Center, Ames Research Center, Dryden Flight Research Center, Langley Research Center, Goddard Space Flight Center, and NASA Headquarters. The Jet Propulsion Laboratory (JPL) is a Federally Funded Research and Development Center; therefore, the JPL employees are not civil servants, and their personnel and related costs are included in direct program costs.

MARSHALL SPACE FLIGHT CENTER (MSFC)

The ESE funds approximately 2% of MSFC's Institution cost. Through the Global Hydrology and Climate Center (GHCC), a joint venture with academia, MSFC engages in research, education, and the development of Earth science applications. The GHCC focuses on using advanced technology to observe and understand the global climate system and applies this knowledge to agriculture, urban planning, water resource management, and operational meteorology.

STENNIS SPACE CENTER (SSC)

The ESE funds approximately 35% of SSC's Institution cost. Through the Applications Program, SSC will enhance U.S. economic competitiveness via commercial partnership programs that apply remote sensing technologies in business applications and reduce new product development costs. As part of the Applied Research and Data Analysis program, SSC will conduct fundamental and applied research, which increases our understanding of environmental systems sciences, with emphasis on coastal research of both land and oceans.

AMES RESEARCH CENTER (ARC)

The ESE funds approximately 6% of ARC's Institution cost. ARC builds instruments and computer models for measurement and analysis of atmospheric constituents and properties from aircraft platform are being developed. Applied research and developments to enhance the use of remote and in-situ sensing technology for Earth resources applications continues. ARC provides information systems and high end computing support for Earth Sciences knowledge acquisition.

DRYDEN FLIGHT RESEARCH CENTER (DFRC)

The ESE funds approximately 7% of DFRC's Institution cost. DFRC conducts flight operations in support of Airborne Science Missions utilizing aircraft for data collection and observation.

LANGLEY RESEARCH CENTER (LaRC)

The ESE funds approximately 14% of LaRC's Institution cost. LaRC performs an agency-designated Atmospheric Science mission role in support of the ESE in the NASA Strategic Plan. As Lead Center for Focused Atmospheric Science Missions, LaRC conducts a world-class peer reviewed and selected atmospheric science program in support of national goals in preserving the environment and in fundamental science. Specific LaRC discipline areas of expertise are Earth radiation research, particularly the role of clouds in the Earth's energy budget; middle and upper atmospheric research; and tropospheric research. LaRC performs innovative scientific research to advance the knowledge of atmospheric radioactive, chemical, and dynamic processes for understanding global change; develops innovative passive and active sensor systems concepts for atmospheric science measurements. LaRC conducts a technology development program that develops advanced laser and LIDAR technologies for Earth science missions; advanced passive remote sensing technologies; develops advanced ultra-lightweight and adaptive materials, structural systems technologies and analytical tools for significantly reducing the end-to-end cost and increasing the performance of earth observation space instruments and systems. LaRC conducts an Application, Education and Outreach program that utilizes scientific data for non-scientific applications and in support of science and math education. LaRC also serves as a Primary Data Analysis and Archival Center (DAAC) for Earth Radiation and Atmospheric Chemistry for the Earth Observing System.

GODDARD SPACE FLIGHT CENTER (GSFC)

The ESE funds approximately 38% of GSFC's Institution cost. GSFC is the Lead Center for Earth Science. This process and modeling research effort will provide the basis for establishing predictive global change models for policy makers and scientists.

GSFC manages the Earth Explorers Program and conducts science correlation measurements from balloons, sounding rockets, aircraft and ground installations. It also manages, on a reimbursable basis, the acquisition of meteorological observing spacecraft for the National Oceanic and Atmospheric Administration (NOAA).

Lead Center for the Independent Verification & Validation (IV&V) Facility in Fairmont, West Virginia. The IV&V Facility is responsible for providing independent assessments of project software and for the management of all software IV&V efforts within the Agency.

JET PROPULSIN LABORATORY (JPL)

The ESE funds approximately 14% of JPL's Institutional cost. The JPL funding requirements include the Emergency Supplemental to enhance NASA's security counterintelligence and counter-terrorism capabilities, the environmental cleanup effort, and the CoF activities.

NASA HEADQUARTERS (NASA HQ)

The ESE funds approximately 20% of NASA HQ's Institution cost. The mission of NASA HQ is to plan and provide executive direction for the implementation of U.S. space exploration, space science, Earth science, aeronautics, and technology programs. This includes corporate policy development, program formulation, resource allocations, program performance assessment, long-term institutional investments, and external advocacy for all of NASA.

At NASA HQ, the broad framework for program formulation will be conducted through ESE. Consistent with the NASA strategic plan, the ESE develops program goals and objectives to meet the needs of external customers within the policy priorities of the Administration and Congress.